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January 1989

# Center for Decision Studies



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The Fuqua School of Business
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Durham, North Carolina 27706

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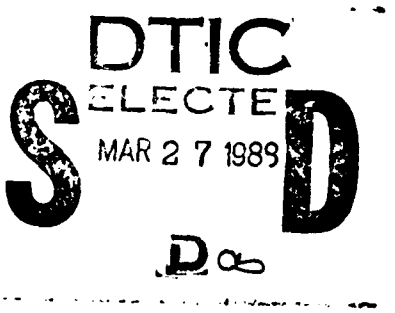


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January 1989

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In order to better understand the cognitive processes underlying judgment and choice, decision researchers have begun to use a variety of process tracing techniques. The idea is to complement many traditional measures of judgment and choice with a high density of observations on the intermediate stages of processing. This report documents a procedure for monitoring the information acquisition stages of decision behavior. The procedure is based on a micro-computer controlled pointing device called a mouse. The procedure offers a number of flexible graphics and data recording routines. The relationship of the procedure to other process tracing techniques is discussed.

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# 1.0 Background.

Much current decision research attempts to identify the cognitive processes underlying judgment and choice (see Einhorn & Hogarth, 1981; Pitz & Sachs, 1984). To better understand those processes, investigators are increasingly adopting process tracing techniques to complement many traditional final output measures such as choice proportions, rankings, or ratings. This paper explains and documents a methodology which facilitates process tracing studies of information acquisition and decision making.

The two process tracing methods of greatest interest to decision researchers have been: (1) verbal protocol analysis, and (2) the analysis of information acquisition behavior. Verbal protocol analysis takes as data the continuous verbal reports provided by a subject who is asked to "think aloud" while performing a decision task. An utterance at a particular point in time is taken to indicate knowledge or an operation at that time (Newell & Simon, 1972). A model of how people respond to instructions to think aloud is developed by Ericsson and Simon (1980; 1984). Ericsson and Simon argue forcefully for the validity of verbal protocols in providing a high density of observations of the intermediate stages of processing, and they provide numerous examples of the successful use of verbal protocols in the study of cognitive processes.

Information acquisition analysis is based on data concerning what information the subject seeks, the sequence of acquisition, how much information is acquired, and for what duration information is examined. Typically these data have been obtained from tasks where subjects acquire data from a matrix of several alternatives, each described on several attributes. Data on information acquisitions is important for several reasons. First, the evaluation strategies that have been proposed in the decision literature imply certain patterns of search (Payne 1976). Second, information acquisition relates to the role of attention and memory in decision making, a relatively neglected area of study (Einhorn & Hogarth, 1981). Finally, understanding the amount, types, and pattern of information acquisition is important in the design of

decision aids ranging from labels on packages to computer-based decision support systems. Further arguments for adopting verbal protocol analysis and the monitoring of information acquisition behavior in decision research are provided by Payne, Braunstein, and Carroll (1978).

In principle, verbal protocols can provide data on information search behavior as well as additional process data. Obviously, a person might report each item of information examined. An example of additional process data would be reports of recall from long-term memory. However, there are a number of reasons why monitoring information acquisition behavior might complement or supplement verbal protocols. First, in some decision tasks, subjects will fail to provide a complete verbal report of all the information acquired. Complementing verbal protocols with a decision task structured so that subjects' information selections can be easily monitored ensures a more complete record of the information processing. Monitoring information acquisition is also a much easier form of process tracing. While the coding of information acquisitions is not always as straightforward as it might seem, it is generally easier than the coding of verbal reports. Russo (1978), in his critical evaluation and comparison of process tracing techniques, states that "the most important point about verbal protocols is that they are difficult to analyze formally" (p. 564). Finally, in spite of the arguments of Ericsson and Simon (1984), there is concern that generating a verbal report is a secondary task that must be performed along with the primary decision task (Russo, Johnson, & Stephens, 1985). Such a secondary task will certainly slow down the decision process substantially, and perhaps fundamentally alter the process. For these reasons, the monitoring of information acquisition behavior has seen widespread acceptance in decision research as a process tracing methodology.

If one wants to monitor information acquisition, what is the best technique to use? At one extreme are simple "information board" procedures. For example, in Payne (1976) the information board consisted of a matrix of envelopes attached to a sheet of cardboard. To obtain the value on a particular dimension for a particular alternative, the subject had to pull a card out of the appropriate envelope, turn it around, read the card, and place it back into the envelope. The value was printed on the back of the card. Similar types of information boards have been used successfully in a number of studies. However, a major criticism of information boards is their reactivity, due to the time and effort required to acquire a piece of information (Arch, Bettman, and Kakkar 1978). At the other extreme is the monitoring of information acquisition using

sophisticated techniques for the recording of eye fixations. Russo and his associates have been the primary users of eye movement recording to study decision behavior. Russo and Dosher (1983) used a photoelectric sensing device and a computer for recording and analyzing the fixations. One disturbing feature of this methodology is that the eye-position sensor required that the subject's head be immobilized by a bite bar. However, Russo and Dosher state that subjects adjusted quickly to the apparatus, and they believed that it had no influence on the choice processes. Another factor that has limited the use of eye movement recording is the complexity and expense of the equipment. As Russo (1978) acknowledges, to record eye movements precisely requires a "quite expensive" system. Just and Carpenter (1984), who have used eye fixations in a variety of cognitive tasks from reading to problem solving, also view the cost of instrumentation and cost of training personnel as major limitations of the eye movement methodology. Yet, despite these problems, monitoring eye fixations has proved informative.

In one of the few efforts to directly compare various information monitoring techniques, Russo (1978) reports that eye movements typically required a minimum of 200 - 300 milliseconds. On the other hand, a physical retrieval of information from an information display board could involve 3 - 4 seconds. One consequence of this difference in acquisition time (effort) was that subjects seldom reacquired information in information display board studies. Russo (1978) reviews several information display board studies and his own work using eye-movement recording and reports that the reacquisition rate for information boards never exceeded 7% of all acquisitions. On the other hand, the reacquisition rate with eye-movements was as high as 56%. As Russo notes, differences in stimulus materials make comparisons across studies somewhat imprecise. Nonetheless, the reacquisition rate is likely to be much higher with eye movements. More generally, information display boards yield a much sparser pattern of observations than eye-movement recording. Consequently, Russo argues that there is a danger that the less dense data set may yield misleading conclusions about a decision maker's strategies.

As an alternative to simple information boards and to expensive and difficult to use eye movement recording, we propose a new methodology for monitoring information acquisition behavior. That methodology uses computer graphics to display information which is accessed using a computer-based pointing device called a "mouse". The methodology comes close to the recording of eye movements in terms of speed and ease of acquisitions, while minimizing instrumentation cost and the difficulty of use for

both subject and experimenter. The rest of this report documents such a methodology.

## 2.0 The Mouse.

There are a number of computer-based pointing or position entry devices such as a lightpen, joystick, directional cursor keys, and mouse. Of these devices, the mouse has three marked advantages (Card, Moran & Newell, 1983).

The first advantage of a mouse as a pointing device is ease of learning. Card, Moran, and Newell (1983) compared the mouse, joystick, and two key operated devices for selecting text on a screen. Although each of the devices yields improved performance with practice, research indicates that the mouse and joystick have a significantly faster rate of learning than using cursor keys. In our experience, even people unfamiliar with computers are relatively comfortable with the mouse after a brief training period of five to ten minutes.

A second major advantage of a mouse is its rapid movement. Card, Moran, and Newell found the mouse to be significantly faster than the other devices they tested. An earlier study by English, Englebart, and Berman (1967) found the mouse faster than a lightpen and several other devices. An analysis of the time to move the mouse from point to point suggests that this follows Fitts Law (Card, Moran, & Newell, 1983). They suggest that the time to move a mouse is primarily limited by the central information-processing capacities of the eye-hand guidance system. In other words, the major limitation in speed is due to the time it takes to think where to point, not in the movement of the mouse. Further analysis of the performance of the mouse indicated that it was within 5% of this optimal pointing device described by Fitts Law. We have done an analysis of one of our decision tasks using Fitts Law (see Appendix B), which indicates that subjects could move between information cells in less than 100 milliseconds, a figure we have occasionally observed with practiced subjects. Surprisingly, these times are of similar magnitude to eye-movements, or *about 160 - 200 milliseconds per bit of information* (Card, Moran, & Newell, 1983). This suggests that reactivity due to effort might be minimal.

The third advantage of the mouse is its error rate, the percentage of times that the device is used to select an incorrect item of information. Card, Moran, and Newell report that the mice have a significantly

lower error rate than other devices.

Despite these advantages, the use of the mouse does have limitations. In order to precisely monitor what information is acquired at particular point in time, it is necessary to structure the decision task so that only one item of information is visible at a time. This was done by setting up the decision tasks so that the relevant information is hidden in boxes on the screen until the subject moves the mouse to point at a box. At that time, the box opens and the information is revealed. This procedure eliminates the possibility of the subject's acquiring information from peripheral vision, as might be the case in a more normal visual information environment. Our task is more similar to those used in research in reading, which manipulates the display to remove any peripheral information from around the current eye fixation (Rayner, 1975; McConkie & Rayner, 1976). Apparently, such manipulations have little effect upon the overall ability of an individual to understand text. The manipulations, however, do seem to increase the average time of each fixation, and to diminish the length of the distance covered by each fixation. By analogy, the mouse may have the same effect on search patterns. Specifically, we might see fewer transitions between distant areas of the display. However, reacquisition of information is often seen with the mouse, suggesting that much of the reactivity discussed by Russo is not present.

Ultimately, of course, the comparison of eye-movement recording to a mouse-based information acquisition system will require a series of empirical studies. Nonetheless, the existing evidence suggests that with a mouse-based system the time and effort to acquire a piece of information from a computer display are relatively small. This should reduce the reactivity of studies that examine decision behavior through the monitoring of information acquisition behavior.

The next sections of this paper describe the software that utilizes a mouse to perform a variety of decision experiments.

## 3.0 Overview of the Mouse Decision Laboratory Programs.

The core of the mouse-based system for doing decision studies is a program called MOUSELAB. That program can be used to present the instructions for an experiment, present decision problems using one of five general types of screens or "schemas", and automatically record what information was acquired,

the duration of the acquisition, search order, and the final judgment or choice. Response times are recorded to an accuracy of 1/60th of a second. In addition to MOUSELAB, the decision laboratory software includes a program called BISECT that can be used in the analysis and reduction of the data generated from the process tracing studies. The programs that make up the mouse decision laboratory software are coded in MicroSoft Pascal.

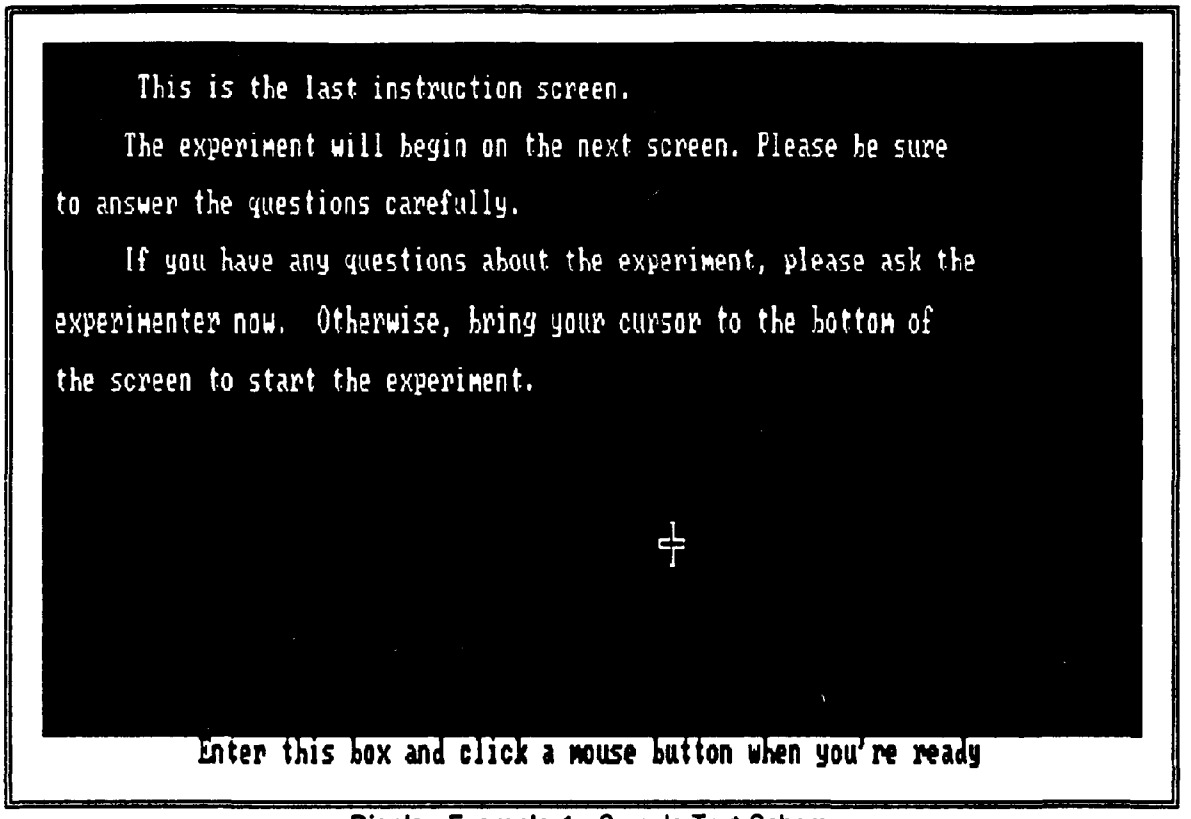
The MOUSELAB program is designed to run on an IBM-PC XT, AT, PS/2 or equivalent. Because of the real time process load, the original IBM PC's system requires an Intel 8087 coprocessor. A recommended system configuration would include an IBM-PC with 320K of memory, two disk drives, and a MouseSystems mouse connected to a serial port. The MOUSELAB will also work with other forms of mice, such as the Microsoft mouse. The computer monitor can be monochrome or color. A graphics card is also required. Currently Hercules, IBM CGA, EGA, VGA, and compatibles are supported.

# 4.0 Display Options.

There are two principal components that together make up a MOUSELAB screen or display. The SCHEMA type determines the manner in which information is displayed on the screen. The RESPONSE MODE determines the manner in which the subject is to respond to the information presented in the schema. Any schema type may be used in conjunction with any response mode (Tversky, Sattath, & Slovic, 1988). MOUSELAB 4.2 supports four different schemas and two different response modes. Each of these is now briefly described.

## 4.1 Schemas.

TEXT: A text schema simply presents lines of text that the researcher wishes to present to the subject (e.g., a set of instructions). Up to 24 lines of text can be presented on a screen. To present additional information on additional screens, the text schema is just evoked repeatedly. See Display Example 1 for sample text schema; Input Example 1 contains the MOUSELAB code used to create the text schema.




**Display Example 1**: Sample Text Schema

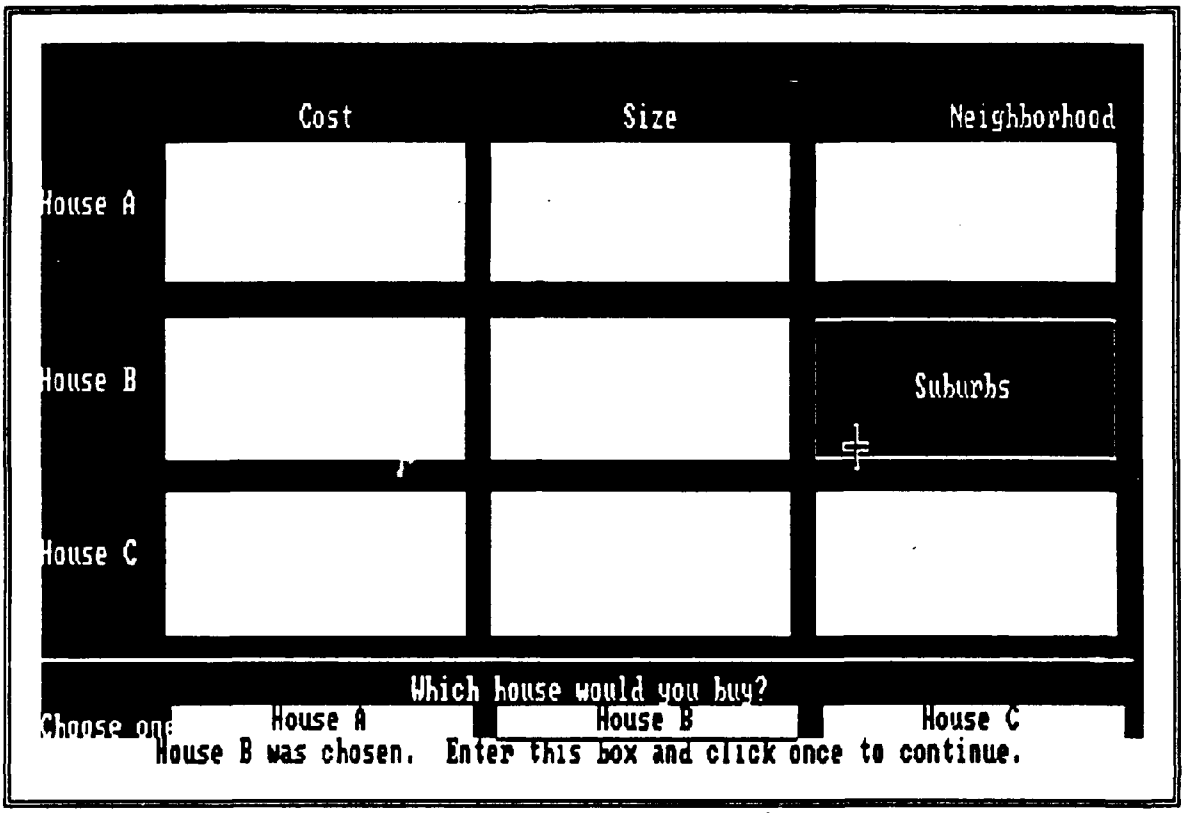
MATRIX: A matrix schema presents an M rows X N columns matrix of boxes which can be opened to display information. Labels can be specified for the rows and columns. Boxes used to choose one of the alternatives appear at the bottom of the screen. The maximum size matrix that we have used corresponded to an 8 alternative X 8 attribute decision problem. This schema is most useful for nonrisky.

```
@BEGIN<TEXT>
@BEGIN<SCREENTEXT>
   This is the last instruction screen.

   The experiment will begin on the next screen. Please be sure
to answer the questions carefully.

   If you have any questions about the experiment, please ask the
experimenter now. Otherwise, bring your cursor to the bottom of
the screen to start the experiment.
@END<SCREENTEXT>
@END<TEXT>
```

**Input Example 1**: Input Format for Text Schema



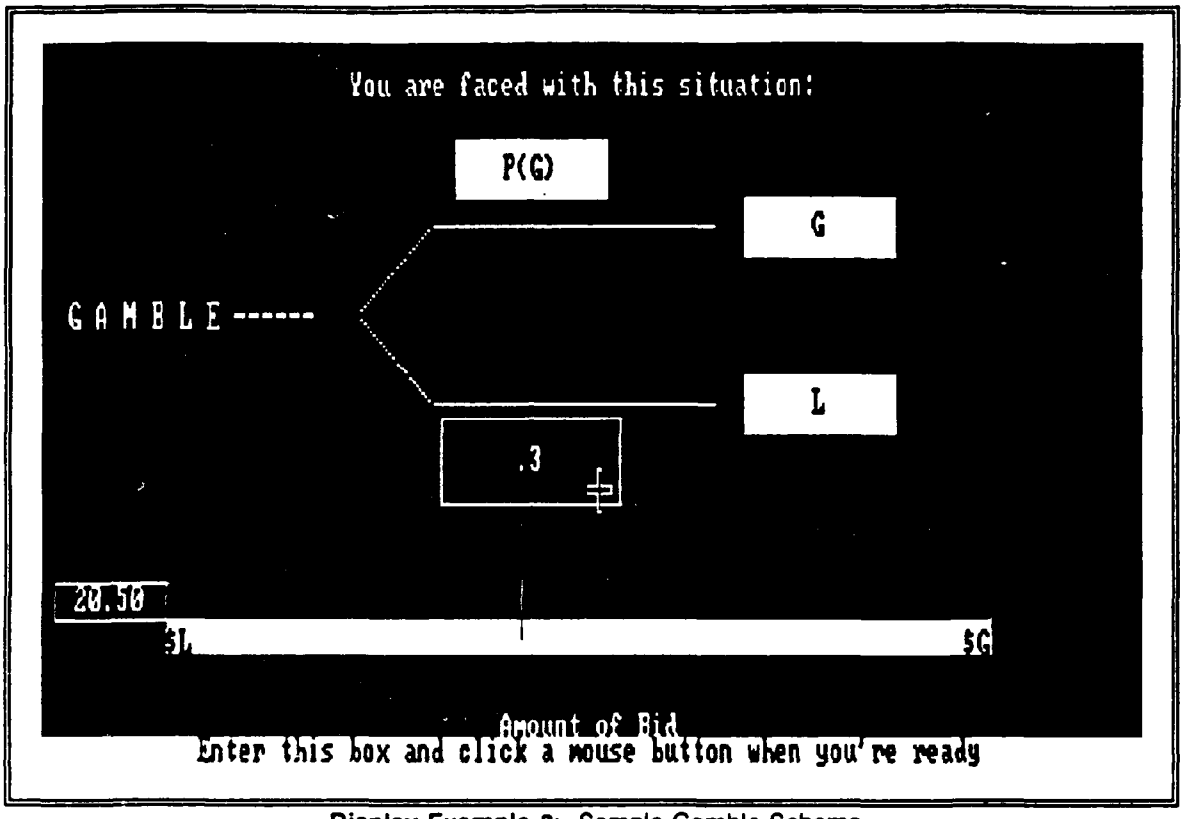

**Display Example 2**: Sample Matrix Schema

multiattribute decision problems. See Display Example 2. Input Example 2 contains the code used to create the Display Example 2.

GAMBLE: A gamble schema presents a two-outcome gamble and a certain option in a format appropriate for either a probability equivalence or a certainty equivalence judgment. See Display Example 3. Input Example 3 contains the code used to create the gamble schema in Display Example 3. A study of

```
@BEGIN<FILE>
@BEGIN<MATRIX>
@SET<RESPONSELINE="Which house would you buy?">
@SET<ALTERNATIVES=3;ATTRIBUTES=3>
@SET<ALT[1]="House A";ALT[2]="House B";ALT[3]="House C">
@SET<ATTRIBUTE[1]="Cost";ATTRIBUTE[2]="Size";ATTRIBUTE[3]="Neighborhood">
@SET<BOX[1,1]="$700,000";BOX[1,2]="Small";BOX[1,3]="Downtown">
@SET<BOX[2,1]="$400,000";BOX[2,2]="Medium";BOX[2,3]="Suburbs">
@SET<BOX[3,1]="$150,000";BOX[3,2]="Large";BOX[3,3]="Country">
@END<MATRIX>
@END<FILE>
```

**Input Example 2**: Input Format for Matrix Schema



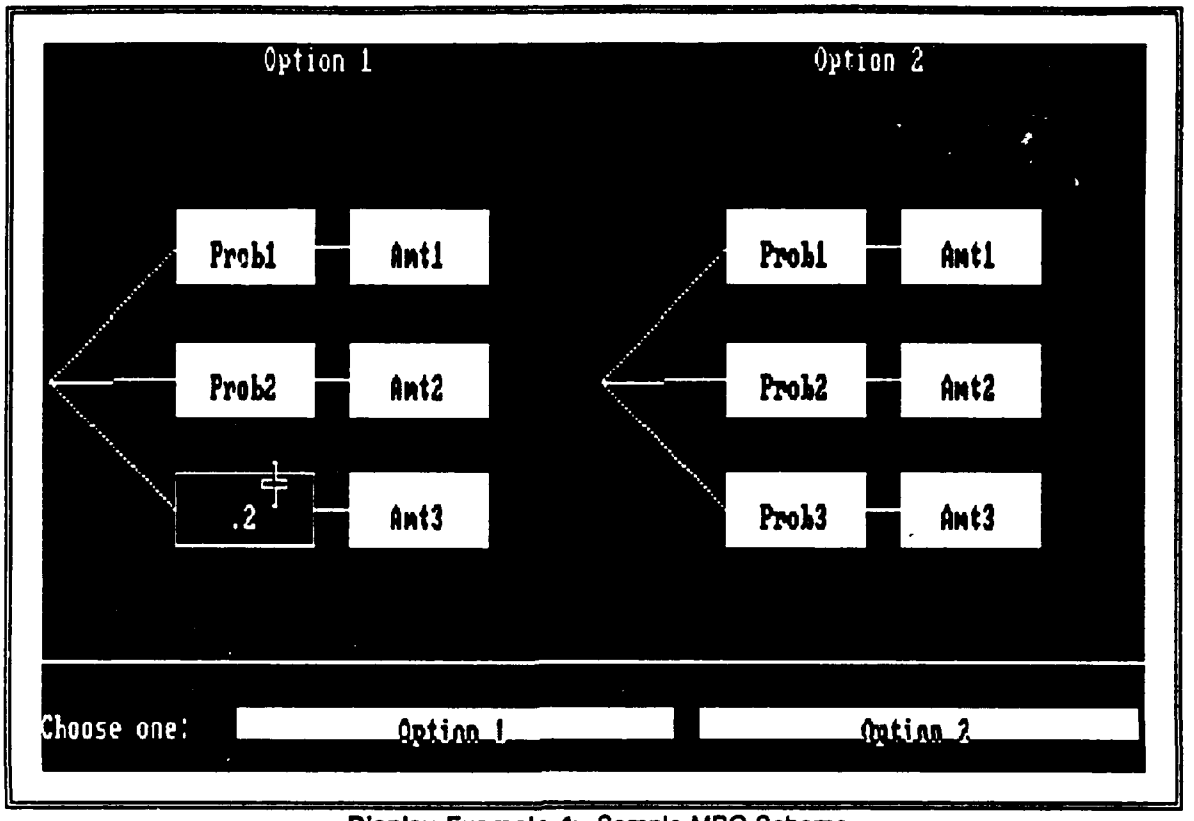

**Display Example 3**: Sample Gamble Schema

preference reversals using this schema is reported in Johnson, Payne, and Bettman (1988).

MRC (Multiple Risky Choice): An MRC schema can be used to present any number of different gambles in a decision-tree format. The gambles in a set can have different numbers of outcomes and attributes, although each gamble in a set must have the same structure. This schema can also be used to present nonrisky multiattribute problems by setting the number of outcomes equal to one. An example of

```
@BEGIN <FILE>
@BEGIN <GAMBLE>
@TITLE <"Demo Amount of Bid">
@SET <GAMBLEMODE = AOB; ANCHORMODE = OFF; ANCHORVALUE = 0>
@SET <HIGHPAY = "$33"; HIGHPAYPROB = ".7";
    LOWPAY = "$11"; LOWPAYPROB = ".3">
@SET <LABELS = 2>
@SET <PUTLABEL[1] = 0.0; LABEL [1] = "$L";
    PUTLABEL[2] = 1.0; LABEL [2] = "$G">
@SET <SCALELEFT = 10;SCALEBOTTOM = 20;SCALESIZE = 60>
@END <GAMBLE>
@EN  <FILE>
```

**Input Example 3**: Input Format for Gamble Schema




**Display Example 4**: Sample MRC Schema

an MRC display is shown in Display Example 4. The code which created Display 4 is in Input Example 4.

## 4.2 Response Modes.

In any schema, an experimenter can choose between two different response modes, representing choice and judgment (Tverksy, Sattath, & Slovic, 1988). Choices are made using the response boxes mode, while judgments are made using the response scale mode.

BOXES: The boxes response mode presents a variable number of labeled choice boxes at the bottom of the screen. To choose a response, the subject simply moves the cursor into the desired response box.

SCALE: The scale response mode presents a horizontal (Likert-like) scale for responses. Scale labels and the numbered divisions of the scale can be specified. See Display Example 5 and Input Example 5.

```
@BEGIN<FILE>
@BEGIN <MRC>
@TITLE <"DEMO: MRC SCREEN">
@SET <GAMBLES = 2; OUTCOMES = 3; ATTRIBUTES = 2>
@SET <ORIENTATION = HORIZONTAL>
@SET <GAMBLE[1] = "Option 1"; GAMBLE[2] = "Option 2">
@SET <BOXLABEL[1,1,1] = "Prob1"; BOXLABEL[1,2,1] = "Amt1";
    BOXLABEL[2,1,1] = "Prob2"; BOXLABEL[2,2,1] = "Amt2";
    BOXLABEL[3,1,1] = "Prob3"; BOXLABEL[3,2,1] = "Amt3">
@SET <BOXLABEL[1,1,2] = "Prob1"; BOXLABEL[1,2,2] = "Amt1";
    BOXLABEL[2,1,2] = "Prob2"; BOXLABEL[2,2,2] = "Amt2";
    BOXLABEL[3,1,2] = "Prob3"; BOXLABEL[3,2,2] = "Amt3">
@SET <BOX[1,1,1] = ".2"; BOX[1,1,2] = "$65";
    BOX[1,2,1] = ".6"; BOX[1,2,2] = "$5";
    BOX[1,3,1] = ".2"; BOX[1,3,2] = "-$50";
    BOX[2,1,1] = ".5"; BOX[2,1,2] = "$40";
    BOX[2,2,1] = ".3"; BOX[2,2,2] = "$0";
    BOX[2,3,1] = ".2"; BOX[2,3,2] = "-20">
@END <MRC>
@END<FILE>
```

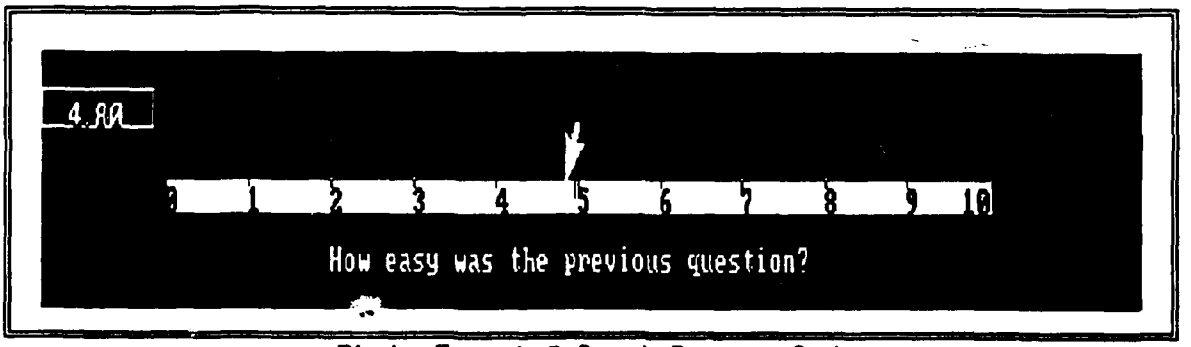
**Input Example 4**: Input Format for MRC Schema

Both response modes provide for a one line message either immediately above or below the response area. This is sometimes useful for clarifying the meaning of possible responses.

## 5.0 Features.

MOUSELAB also supports three general features that can be used with the various displays.

TIME PRESSURE : Time pressure is implemented by depicting an analog clock that counts down for a specified number of seconds. The clock is displayed on the screen along with the information contained in a schema. When the allotted time has expired, the request "Please make a choice or indicate a value" is displayed at the top of the screen. Several other things can happen to the screen, depending

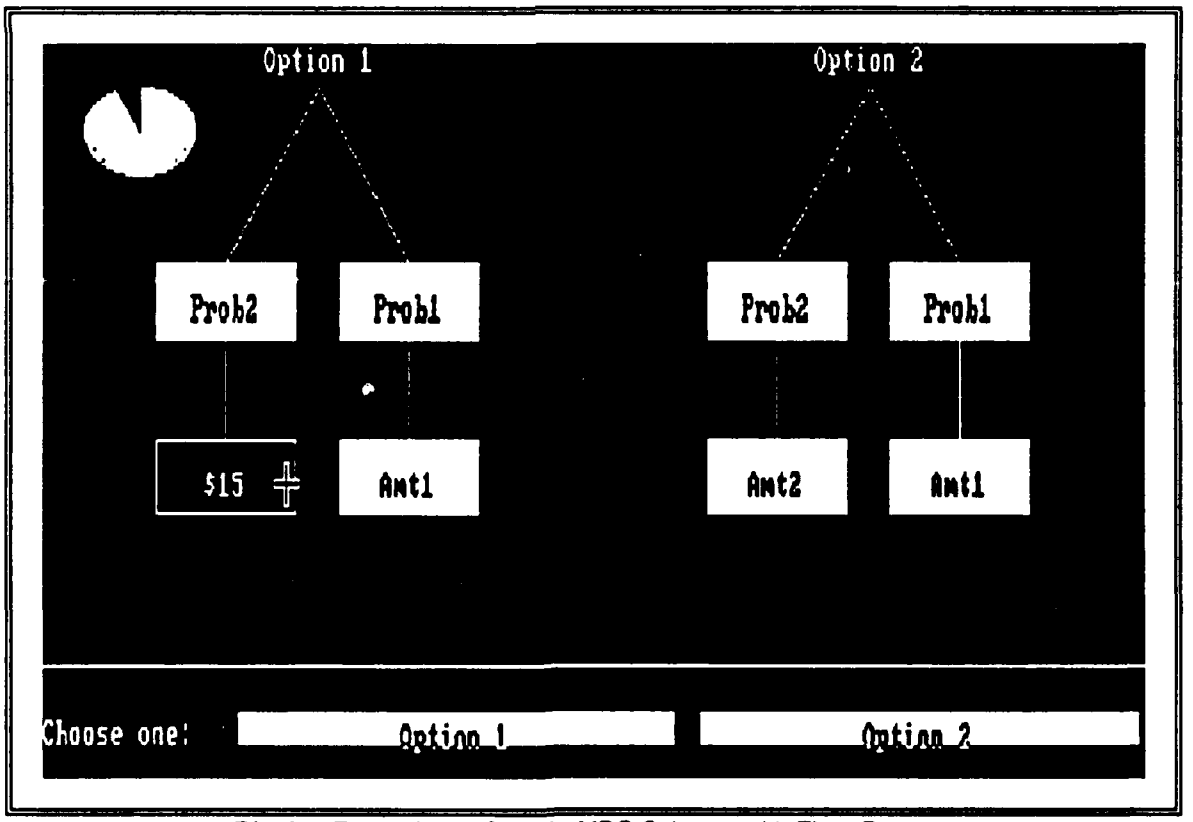



**Display Example 5**: Sample Response Scale

```
@BEGIN<FILE>
@BEGIN<TEXT>
@SET <RESPONSEMODE = SCALE>
@SET <SCALELEFT = 10; SCALEBOTTOM = 12; SCALESIZE = 80>
@SET <LABELS = 11; ANCHORMODE = ON; ANCHORVALUE = 5>
@SET <PUTLABEL[1] = 0.0; LABEL[1] = "0";
    PUTLABEL[2] = 0.1; LABEL[2] = "1";
    PUTLABEL[3] = 0.2; LABEL[3] = "2";
    PUTLABEL[4] = 0.3; LABEL[4] = "3";
    PUTLABEL[5] = 0.4; LABEL[5] = "4";
    PUTLABEL[6] = 0.5; LABEL[6] = "5";
    PUTLABEL[7] = 0.6; LABEL[7] = "6";
    PUTLABEL[8] = 0.7; LABEL[8] = "7";
    PUTLABEL[9] = 0.8; LABEL[9] = "8";
    PUTLABEL[10] = 0.9; LABEL[10] = "9";
    PUTLABEL[11] = 1.0; LABEL[11] = "10">
@SET<RESPONSELINE="How easy was the previous question?">
@END<TEXT>
@END <FILE>
```

**Input Example 5**: Input Format for Response Scale

on what is specified. For example, after the clock has finished, the information boxes can be closed so that no additional information can be acquired, and the subject must make a decision based on only the




**Display Example 6**: Sample MRC Schema with Time Pressure

```
@BEGIN<FILE>
@BEGIN <MRC>
@TITLE <"DEMO: MRC SCREEN">
@SET <CLOCK=ON;TIME=60.0>
@SET <GAMBLES = 2; OUTCOMES = 2; ATTRIBUTES = 2>
@SET <ORIENTATION = VERTICAL>
@SET <BEEPSTATUS = ON>
@set <ENDSTATUS = CLOSEDCHECK>
@SET <GAMBLE[1] = "Option 1"; GAMBLE[2] = "Option 2">
@SET <BOXLABEL[1,1,1] = "Prob1"; BOXLABEL[1,2,1] = "Amt1";
    BOXLABEL[2,1,1] = "Prob2"; BOXLABEL[2,2,1] = "Amt2">
@SET <BOXLABEL[1,1,2] = "Prob1"; BOXLABEL[1,2,2] = "Amt1";
    BOXLABEL[2,1,2] = "Prob2"; BOXLABEL[2,2,2] = "Amt2">
@SET <BOX[1,1,1] = ".4"; BOX[1,1,2] = "$25";
    BOX[1,2,1] = ".6"; BOX[1,2,2] = "$15";
    BOX[2,1,1] = ".7"; BOX[2,1,2] = "$10";
    BOX[2,2,1] = ".3"; BOX[2,2,2] = "$30">
@END <MRC>
@END<FILE>
```

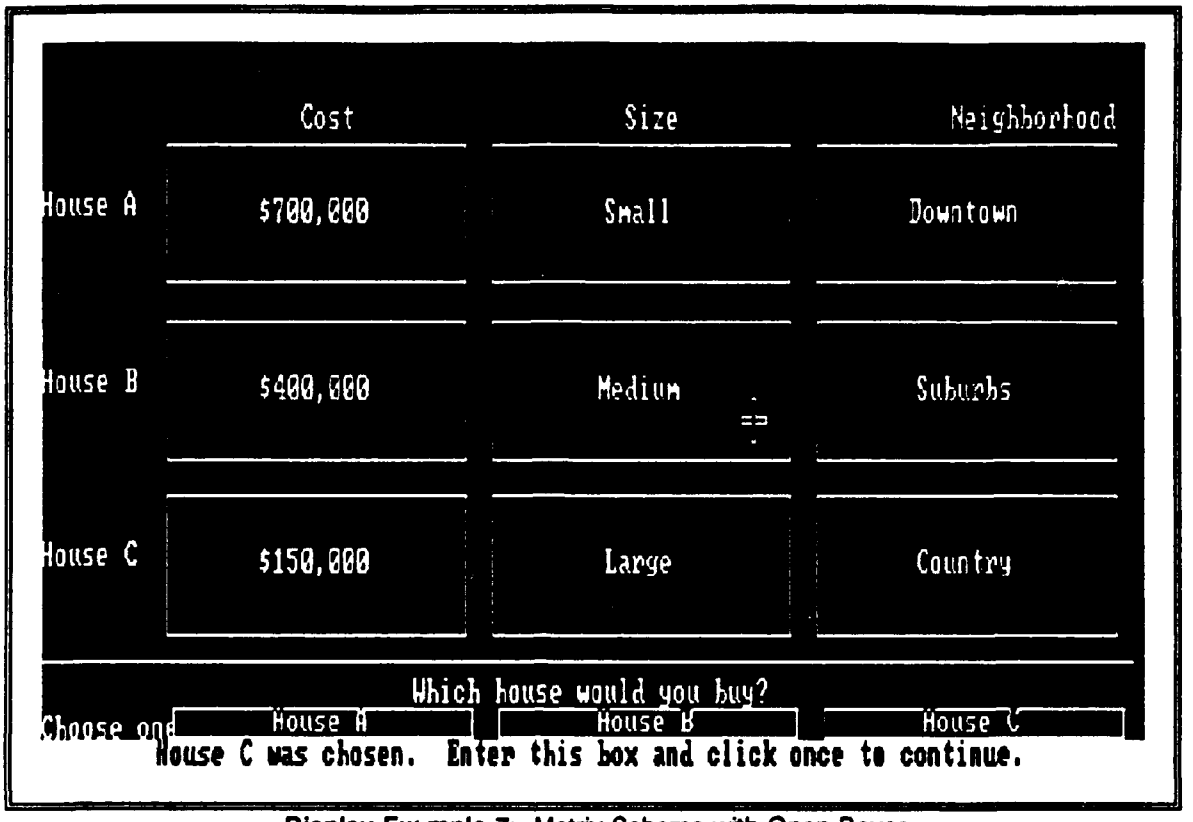
**Input Example 6**: Input Format for MRC Schema with Time Pressure

information acquired up to that point. See Display Example 6 and Input Example 6 for a sample MRC schema with a clock. The time pressure feature was used in a study of adaptive decision behavior by Payne, Bettman, and Johnson (1988).

MOVE CHECKING: On occasion, an experimenter will want to make sure that subjects acquire information in a certain order, perhaps to ensure that a certain decision strategy is followed. One could, for example, use the move-monitoring feature to ensure that a subject used an elimination-by-aspects strategy (Tversky, 1972), which suggests search by attribute. To implement this feature, the experimenter must specify the desired sequence of boxes. If the subject enters any box out of sequence, the box will not open and the PC will emit a beep and record in the output file the time and location of the cursor. Bettman, Johnson, and Payne (in press) provide an example of how this feature might be used to estimate the cognitive effort associated with various decision strategies.

```
@BEGIN<FILE>
@BEGIN<MATRIX>
@SET<BOXES=ON>
@SET<RESPONSE  !E="Which house would you buy?">
@SET<ALTERNATIVE  =3;ATTRIBUTES=3>
@SET<ALT[1]="House A";ALT[2]="House B";ALT[3]="House C">
@SET<ATTR[1]="Cost";ATTR[2]="Size";ATTR[3]="Neighborhood">
@SET<BOX[1,1]="$700,000";BOX[1,2]="Small";BOX[1,3]="Downtown">
@SET<BOX[2,1]="$400,000";BOX[2,2]="Medium";BOX[2,3]="Suburbs">
@SET<BOX[3,1]="$150,000";BOX[3,2]="Large";BOX[3,3]="Country">
@END<MATRIX>
@END<FILE>
```

**Input Example 7**: Input Format for Matrix Schema with Open Boxes




**Display Example 7**: Matrix Schema with Open Boxes

OPEN BOXES: This option uncovers all boxes within a given screen, displaying their normally hidden contents. This feature is useful for experimental validation and for instructional purposes, e.g. to familiarize subjects with the experimental stimuli before introducing the task of acquiring stimuli. Display Example 7 and Input Example 7 contain a sample of a matrix with open boxes.

In addition to these three major options, the user can specify other options as well:

DATA TRACING: The DATA TRACING option allows the researcher to suspend tracing and recording of subject activity within a display. This option is also useful for instructional screens, where there may be no need to monitor subject's behavior.

TRANSPOSE: The transpose option allows a matrix schema to be rotated so that rows become columns and vice-versa. For example, the standard form of display for the matrix schema is to consider the rows as alternatives and the matrix columns as attributes. With the transpose feature, the same input format is used, but the columns become the choice alternatives while the rows become attributes. The

transposition feature can be used to make the display look better or to counterbalance the possible impact of the normal left-right reading order on search behavior.

ORIENTATION: The orientation feature does for MRC schemas what TRANSPOSE does for matrix schemas, displaying the gambles in either horizontal or vertical orientation.

SCALE TRACKING: Normally, when a subject is manipulating a scale, MOUSELAB only records the value of the scale each time the subject changes its value. Scale tracking allows the researcher to monitor the scale adjustment, recording the time and scale value each time the subject changes the direction of adjustment.

SUPPRESSED ALTERNATIVES: This feature works with the matrix and MRC schema to prevent row labels from appearing as choice selections. For instance, if the first row of a matrix was needed to reflect attribute weights, then this option would be used to make sure that "weights" was not one of the choice boxes at the bottom of the screen.

# 6.0 Running MOUSELAB.

The MOUSELAB program runs under IBM PC/DOS. Typically, the diskette containing MOUSELAB.BAT is placed into drive A. The user then types MOUSELAB and hits the enter key. (MOUSELAB.BAT installs METAWNDO graphics, starts the actual MOUSELAB program, and deactivates METAWNDO once MOUSELAB is finished.) The MOUSELAB program will provide prompts for five items of information. First, it will ask which communications port is used for the mouse. For most systems, the response would be either 1 or 2, depending on the serial port to which the mouse is connected. With a Microsoft bus-type mouse, the response would be 32. If you use a PS/2 system and wish to use a serial mouse, then the mouse must emulate a MicroSoft mouse and you must use a COMM code of 32. This is due to hardware problems caused by the mouse port on PS/2 systems. See your mouse manual for details of Microsoft Mouse emulation. The program will next ask for the type of graphics card installed in the PC: Hercules (type in HER), CGA, EGA, or VGA. Third, the program will ask for the name of the main input file (e.g., demo.inp). Fourth, the program will ask for the name of the move sequence file needed to use the move-checking feature (e.g., demo.mov). If the move-checking feature is not used, the response should be

"nul". If move-checking is used, the response would be the appropriate file name. Finally, the fifth prompt requests the name of the data output file to contain the data which MOUSELAB creates while monitoring subject behavior (e.g., demo.out). For the files, any nonreserved file name or extension can be specified: ".inp," ".mov," ".out" are just conventions we have found useful. One can also specify device filenames such as "prn" (see the IBM DOS manual for further details) or "nul". WARNING: "Nul" should be used as a response to the fifth prompt ONLY when you do not want to record data, for no output file will be created.

The MOUSELAB program then reads the specified input file to make the next screen. If move checking is requested, the needed sequence information is read from the given move file. When the subject has finished with a screen, the program writes to the output file and reads the input file to generate the next screen of information. This process continues until all the screens defined in the input file have been displayed.

MOUSELAB makes use of several special files which supply internal program information. There are currently three of these files: TT.MLI, TI.MLI, and PT.MLI. The MLI extensions stand for MOUSELAB Internal. NEVER ALTER ANY FILE WITH AN MLI EXTENSION. Altered MLI files will prevent the program from operating properly.

Once MOUSELAB has started, CONTROL-BKSP (backspace) will abort MOUSELAB, and the message "voluntary abort of MOUSELAB" will appear. If CTRL-BKSP is hit in mid-screen, the abort will not take place until the end of the screen.

## 7.0 Setting Up Input Files.

The preceding section of the paper provided an overview of the MOUSELAB program and the schemas, response modes, and options it supports. In this section, the format and syntax of the input files used by MOUSELAB will be presented, along with elaborations on the various features available. The input files can be created by using any text editor or word processor which is capable of producing normal ASCII output files.

## 7.1 General Input Information.

MOUSELAB input files are written using a special high-level language to specify each display. This language is free format (with one exception which will be discussed later) and is case insensitive. In practice, this means that spaces and line breaks are ignored and any combination of upper and lower case letters may be used. For the sake of clarity, however, this document will use upper case for all commands in its examples.

When MOUSELAB detects a syntax error in an input file, it will halt execution and display a message to that effect, identifying the guilty term and indicating its location in the input file. While MOUSELAB checks for proper syntax, it does not attempt to ascertain if all the required information for a display has been specified. It is incumbent upon the user to make sure that all necessary information has been supplied. If not, unpredictable results are guaranteed.

The MOUSELAB input language consists of three principal elements. These are commands, variables, and values. Commands specify a type of action to be performed. Variables can be thought of as slots that hold the different types of information that describe a display, including whether various features are on or off. Values are the actual information. This information, depending on the variable (or command in those cases in which a command operates directly on a value), can be in the form of numbers, text strings, or special keywords. A command is always preceded by an @ symbol. The variables and /or values on which the command is operating (its arguments) are always enclosed in angle brackets < >. Text strings are usually enclosed in quotation marks. A typical input line might look like this:

@SET<LABELS=3>

"@SET" is the command, "LABELS" is the variable, and 3 is the value assigned to the variable. Each of the six commands in the MOUSELAB input language is now briefly described:

BEGIN: The BEGIN command indicates the beginning of a new input file, a new display specification, or a body of text that is to be displayed, depending on the argument used. Example: @BEGIN<FILE>.

END: The END command indicates the end of an input file, a display specification, or a body of screen text, depending on the argument used. The argument used, however, must be the same as that used in the corresponding BEGIN command. Example: @END<MATRIX>.

COMMENT: The COMMENT command indicates that the enclosed text is a comment and not part of a display. This comment is useful for documenting input files. Example: @COMMENT<A comment does not have to be in quotes.>

TITLE: The TITLE command sends the enclosed text to the output file as the title of the screen in which it is used. This is useful for labeling the output from experiments. Note that any text within a TITLE command must be in quotation marks. Example: @TITLE<"Part 2, Trial 5">.

SET: The SET command assigns values to variables and is therefore the most frequently used command. Any number of assignments can be made with a single SET command as long as they are separated by semicolons. Example:

@SET<LABELS=5>

@SET<SCALELENGTH=50>

are equivalent to the single statement:

@SET<LABELS=5;SCALELENGTH=50>

RESET: The RESET command resets a particular group of variables, referred to as local variables, to their original default values. Local variables are explained in greater detail below. Example: @RESET.

There are two classes of variables in the MOUSELAB input language -- global and local. Local variables control certain frequently used MOUSELAB features. When MOUSELAB starts, these variables are automatically assigned default values. If these values are changed within a display, the change is local to that display. After MOUSELAB has finished processing that display, the values of these variables are automatically restored to their original default values. At some point, the user may wish to change the default value of a local variable. To do this, the local variable must be reassigned by a SET command in between displays instead of within a display. The variable will then retain this new default value until the end of the input file, or until the RESET command is used. The RESET command restores all local variables to their original default values. This capability allows the user to avoid constantly reassigning values to these variables. Note also that the RESET command cannot be used for individual local variables -- once the RESET command is used, all local variables return to their original default value.

Global variables, on the other hand, will retain their assigned values until the user reassigns new values to them. Retained global values are most useful when identical schemas occur consecutively. For

example, if the user specifies a matrix schema followed by another matrix schema, he/she can assume that all of the global variables from the previous schema retain their previous values. Thus, the user does not have to respecify the matrix. But, if identical schemas do not occur back to back, global values will not be retained. For example, if the user specifies a matrix schema followed by a gamble schema followed by another matrix schema, the values specified for the first matrix schema will not be retained for the second matrix schema. (The user will have to fully specify the second matrix schema.) Note that this problem does not occur if the same schema is used with different response modes. As we proceed, we will indicate which variables are local variables. Any variables not explicitly identified as local variables are global variables.

The first command in an input file is always the @BEGIN<FILE> command. Likewise, the last command in an input file is always the @END<FILE> command. Between these two commands, any number of displays may be defined.

Two commands may only be used at certain points in the input file. The RESET command may only be used between display definitions. The TITLE command may only be used within display definitions and only once within each definition. The COMMENT and SET commands may be used at any time.

## 7.2 Locating the Scale and Clock.

Most of the screen elements are located in positions determined by the schema. However, explicit specification of screen location is needed for the positions of the response scale and time-pressure clock. The position of these objects on a MOUSELAB screen is described by an ordered pair, indicating its x and y coordinates. The screen is divided from top to bottom into 24 rows, and from left to right into 80 columns. The coordinates of the top left corner of the screen are (1,1). The bottom right corner is (24,80). All location specifications are expressed in terms of these units.

For example, to tell MOUSELAB where to put a response scale, the user would have to specify appropriate x,y coordinates.

## 7.3 Response Modes.

This section describes the two basic response modes available with MOUSELAB: choice and judgment. Choices are made using the response boxes mode, while judgments are made using the response scale mode.

### 7.3.1 Response Boxes.

Response boxes appear at the bottom of a display and offer the subject a choice of responses. To select a response, the subject simply moves the cursor into the chosen box and presses a button on the mouse. Response box labels are visible regardless of whether the box is open or closed. The subject may change his/her mind simply by moving the cursor into a different response box and pressing a mouse button again. A choice is not final until the subject is satisfied with his/her own response and indicates that he/she has completed that display.

To specify the BOXES response mode, one would use the command @SET<RESPONSEMODE = BOXES>. The number and contents of the response boxes must also be specified. The command @SET<RESPONSES = 2> indicates that there should be two response boxes at the bottom of the screen. (RESPONSES can take on any positive integer value.) Each response box now needs a text string as a label. Assigning RESPONSES a value of 2 automatically creates two label variables, RESPONSE[1] and RESPONSE[2]. The number of label variables will always be equal to the number of response boxes. The command @SET<RESPONSE[1] = "Response 1";RESPONSE[2] = "Response 2"> would label the first response box (the response box furthest to the left) as Response 1 and the second response box as Response 2. Note that the indices after RESPONSE must be integers and are always enclosed in the square brackets.

If necessary, a line of text may be placed just above the response boxes for clarification. The text may be up to 80 characters in length and is specified with a command of the form @SET<RESPONSELINE = "Which response do you choose?">. The contents of the RESPONSELINE variable are cleared after each

display.

As will be discussed later, each display schema has a default response mode. Use of the default response mode can be assured with the command @SET<RESPONSEMODE = DEFAULT>. RESPONSEMODE is also a local variable with a program default value of DEFAULT.

### 7.3.2 Response Scales.

The scale response mode is selected with the command @SET<RESPONSEMODE = SCALE>. To understand the commands that describe the scale, it is necessary to understand how screen locations are specified, as explained in Section 7.2.

The command @SET<SCALELEFT = 10> places the left end of the scale 10 (out of 80) columns from the left side of the screen. The command @SET<SCALEBOTTOM = 20> places the bottom of the scale 20 lines from the top of the screen. Finally, @SET<SCALESIZE = 60> indicates the scale is to be 60 columns long. These commands describe a scale that starts 10 positions from the left (x-coordinate), on row 20 from the top (y-coordinate), and extends 60 positions to the right. We have found that values of 10, 20, and 60 work well for SCALELEFT, SCALEBOTTOM, and SCALESIZE respectively and suggest you try these values as a starting point.

The scale must also be labeled. The command @SET<LABELS = 3> informs the program that the scale will have three labels. Each label must be defined as a text string. The position of each label must be explicitly defined from 0.0 to 1.0, 0.0 corresponding to the far left end of the scale and 1.0 to the far right end. For example, @SET<PUTLABEL[2] = 0.5; LABEL[2] = "5"> instructs the program to place the second label (5) at the midpoint of the scale.

Position along the scale is indicated by a pointer, or upside-down arrow. The mouse must first be positioned anywhere on the top half of the scale. A button on the mouse is then pushed, transforming the cursor into a pointer on the scale. The mouse is then used to move the pointer along the scale. (The scale mode also provides a digital readout of the pointer position on the scale.) When the desired scale value has been found, the final response is recorded by pushing the button once more. The cursor reappears, and a small "hairline" cursor marks where the subject exited the scale. Also, a subject may wish to reenter the

scale to change his/her response. To reenter, a subject must touch the cursor to the hairline marker and press a button. The pointer will reappear, and the subject may readjust their response.

Normally, MOUSELAB automatically uses the end labels to calculate scale positions. This necessitates the use of numeric end labels. (Note that MOUSELAB can automatically handle dollar signs, though.) However, non-numeric end labels (e.g., "Min" and "Max") may be specified by using the SCALERANGE option. The command @SET<SCALERANGE = ON> activates this feature. The user specifies the scale range with a command of the form @SET<SCALEMIN = 0; SCALEMAX = 100>. This command informs the program that the scale position will range from a minimum value of 0 to a maximum value of 100. The values assigned to SCALEMIN and SCALEMAX must be positive integers. SCALERANGE is a local variable with a default value of OFF.

An initial position of the scale's hairline cursor may be specified by the command @SET<ANCHORVALUE = 50>. The initial position is given as an integer from 0 to 100, with 0 corresponding to the far left end of the scale and 100 to the far right end. In this case, the scale cursor would appear at the midpoint of the scale. The anchoring option is turned on by the command @SET<ANCHORMODE = ON>. Note that the values ON and YES, OFF and NO are always interchangeable. ANCHORMODE is a local variable with a default value of OFF or NO. This feature is useful for investigating aspects of the anchoring and adjustment heuristic (Slovic & Lichtenstein, 1972; Tversky & Kahneman, 1974).

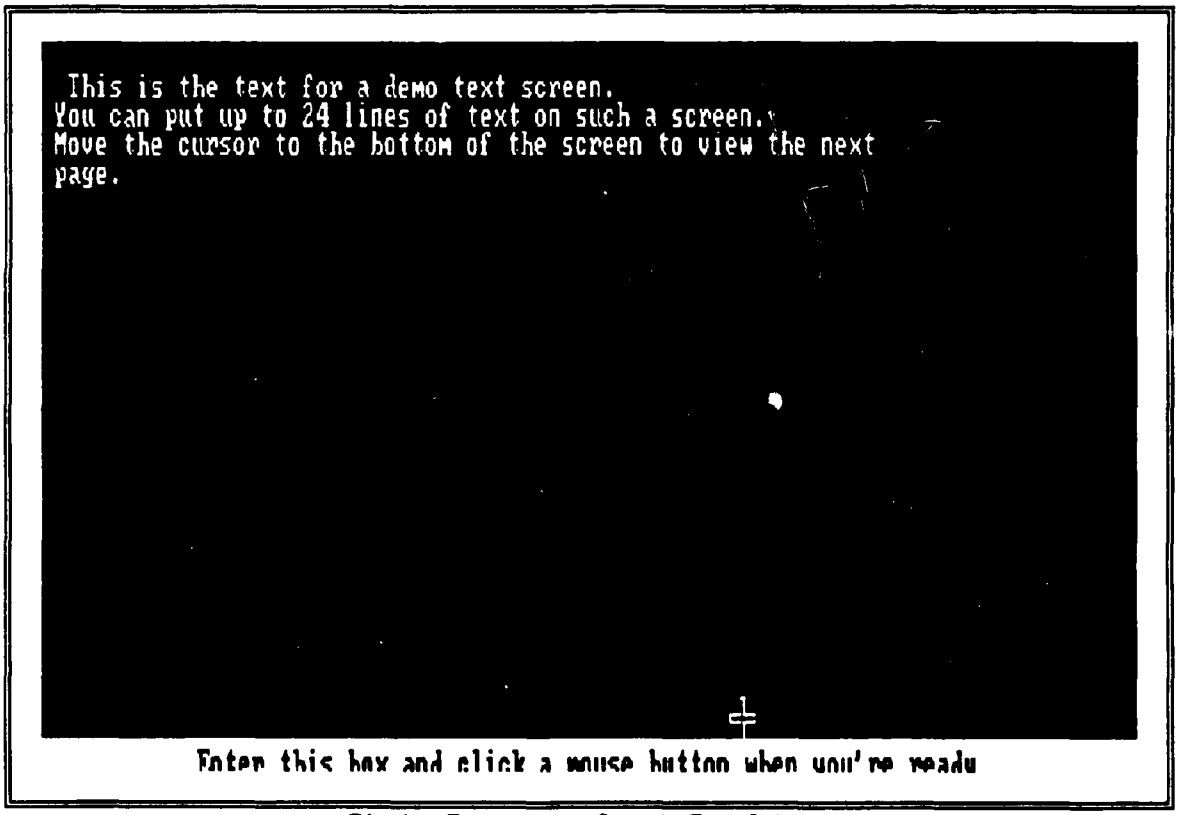
A RESPONSELINE may also be specified in the same manner as for the BOXES response mode. In the SCALE mode, the line of text appears at the bottom of the screen. For an example of a response scale, please turn back to Display Example 5 and Input Example 5.

## 7.4 Text Schema.

A text schema display definition would start with the @BEGIN<TEXT> command. To specify a screen of text to be displayed, the user would insert an @BEGIN<SCREENTEXT> command. Starting on the following line, the user can specify up to 24 lines of text to be displayed. This text will be displayed exactly as it appears in the input file. On the line immediately following the last line of text to be displayed,

the user places an @END<SCREENTEXT> command. This must be the only text on this line, otherwise MOUSELAB will interpret it as another line of display text. Following any additional commands (specifying a response mode, for example), the display definition would end with an @END<TEXT> command.

Screen text is always specified as described above and is the one exception to the free format rule. In addition, there is no default response mode for a text schema. This is the only schema which can be used without a response mode. If no response mode is designated, the message "Ente this box and click a mouse button when you're ready" is placed at the bottom of the screen automatically. This enables subjects to continue on to the next display after having read the text contained in the screen. If an experimenter desires a response mode within a text schema, the response mode must be specified between the "@END<SCREENTEXT" and the "@END<TEXT" commands. See Display Example 8 and Input Example 8 for a sample text schema.




**Display Example 8**: Sample Text Schema

```
@BEGIN <FILE>
@BEGIN <TEXT>
@TITLE <"DEMO TEXT SCREEN">
@COMMENT <THIS IS THE TEXT FOR A DEMO TEXT SCREEN.>
@BEGIN <SCREENTEXT>
This is the text for a demo text screen.
You can put up to 24 lines of text on such a screen.
Move the cursor to the bottom of the screen to view the next
page.
@END<SCREENTEXT>
@END <TEXT>
@END <FILE>
```

**Input Example 8:** Input Format for Text Schema

## 7.5 Matrix Schema.

The matrix schema is one of the most powerful schemas supported by the MOUSELAB program. Consequently, the matrix input specification is a bit more complex. However, a matrix display definition still conforms to the same general pattern as all other schemas.

Like other schemas, a matrix display definition begins and ends with BEGIN and END commands with the appropriate argument. In this case, the commands are @BEGIN<MATRIX> and @END<MATRIX>. Since the MOUSELAB input language is free format, the following information may be provided to the program in any order using the SET command.

In order to process a matrix display definition, the program must know the size of the matrix. The alternatives of the matrix correspond to its rows. The command @SET<ALTERNATIVES = 4> tells MOUSELAB that there are to be four rows in this matrix. The number 4 in the command could be replaced with any positive integer. The attributes of the matrix correspond to its columns. The command @SET<ATTRIBUTES = 3> indicates there will be three columns. Again, any positive integer may be substituted for the number used here. There are no formal limits on the size of matrices. Practical limits, however, result from the size and resolution of your screen. We suggest you experiment to get a feel for these limits. For many displays, a 6 X 8 matrix is a practical maximum.

Of course, MOUSELAB also needs labels for the alternatives and attributes. The command @SET<ALTERNATIVE[1] = "Newport"> indicates that alternative number 1 is Newport. Likewise, the second alternative could be specified by @SET<ALTERNATIVE[2] ="Chapel Hill">. As previously

discussed, indices for variables must be integers and must be enclosed by square brackets. The labels for the attributes can be specified in similar fashion. For example, @SET<ATTRIBUTE[1] = "Costs"> indicates that the first attribute is Costs. Moreover, because of MOUSELAB's ability to recognize abbreviations, the labels can be specified more conveniently by commands such as @SET<ALT[1] = "Newport"> and @SET<ATTR[1] = "Costs">.

MOUSELAB also needs specification of the contents of the boxes of the matrix. The command @SET<BOX[1,2] = "Excellent"> indicates that the contents of the box for the first alternative and its second attribute should be Excellent. For each BOX, the first index refers to the alternative or row number while the second index refers to the attribute or column number. Multiple indices are always separated by commas.

Note, however, that in the output file, the matrix boxes are referenced by a single number. A 4 x 3 matrix, for example, is numbered this way in terms of program output:

1 2 3

4 5 6

7 8 9

10 11 12.

If the BOXES response mode was used, the choice boxes would be numbered starting with 13 and proceeding left to right. The multiple index method of referencing matrix boxes is used only in the input file.

As noted above, the alternative labels appear on the left side of the matrix and the attribute labels at the top in this, the normal screen orientation. If the TRANSPOSE option is switched on, the alternative labels would appear at the top of the matrix and the attribute labels on the left side. The input specifications, however, would remain the same, as would the box references in the output file. To transpose a matrix, the command would be @SET<TRANSPOSE = ON> or @SET<TRANSPOSE = YES>. Thus, the box references in the output file will look like this:

1 4 7 10

2 5 8 11

3 6 9 12.

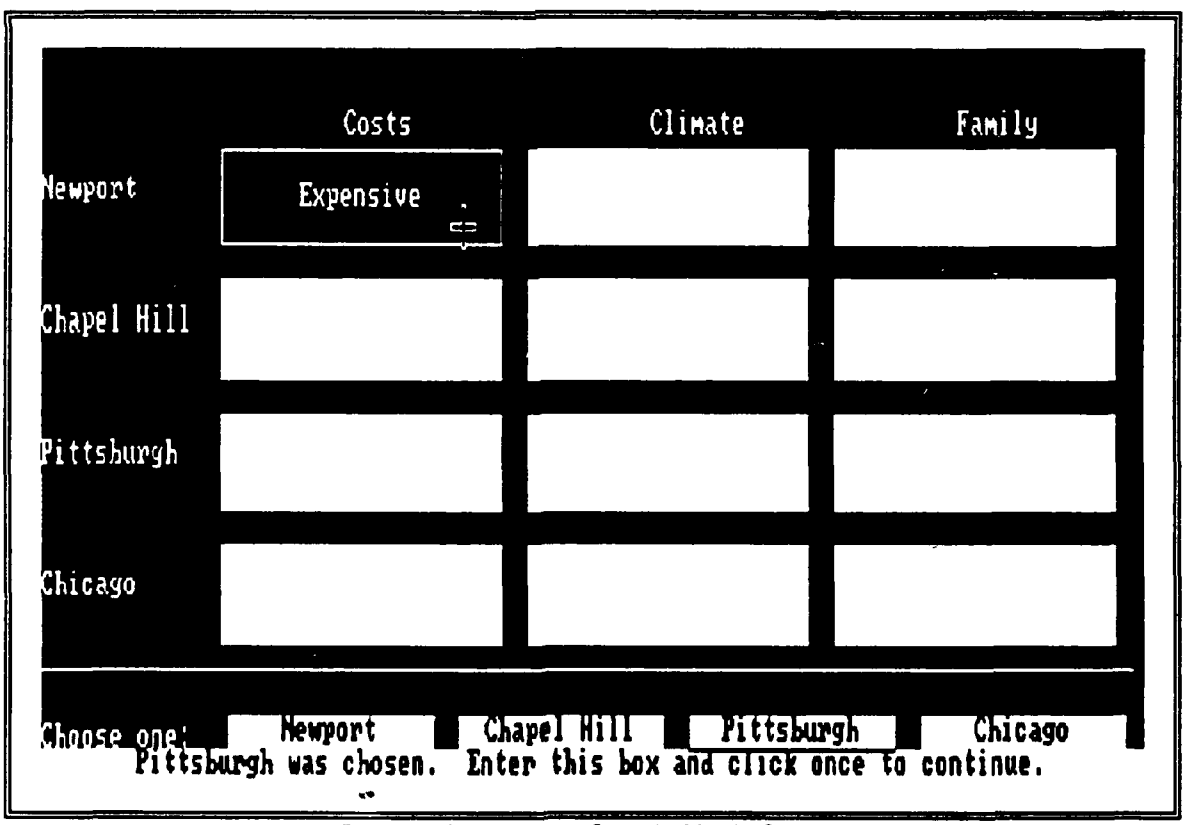
The default response mode for a matrix schema is BOXES. Moreover, when the response mode is specified as DEFAULT, the labels of the alternatives (regardless of whether the matrix is transposed) are

automatically used as the labels of the response boxes. In the DEFAULT mode, all response made details are handled automatically so that no other specifications are required.

If, however, the researcher does not want all of the alternatives to appear as response choices, he/she can use the suppressed alternatives feature. This feature prevents the first n alternatives from appearing as possible responses. This is accomplished with a command such as @SET<SUPPRESSED = 2>. It would suppress the first two alternatives specified; the first response box would therefore correspond to alternative number 3. This feature is useful if one wishes to include such things as attribute weights in the matrix.

Matrix schemas may also be used in conjunction with the move checking feature.

The next example adds a row of decision weights to a 3 x 3 choice matrix. The weight row is now suppressed. See Display Example 10 and Input Example 10 for a transposed matrix with one attribute column (no longer row) suppressed.



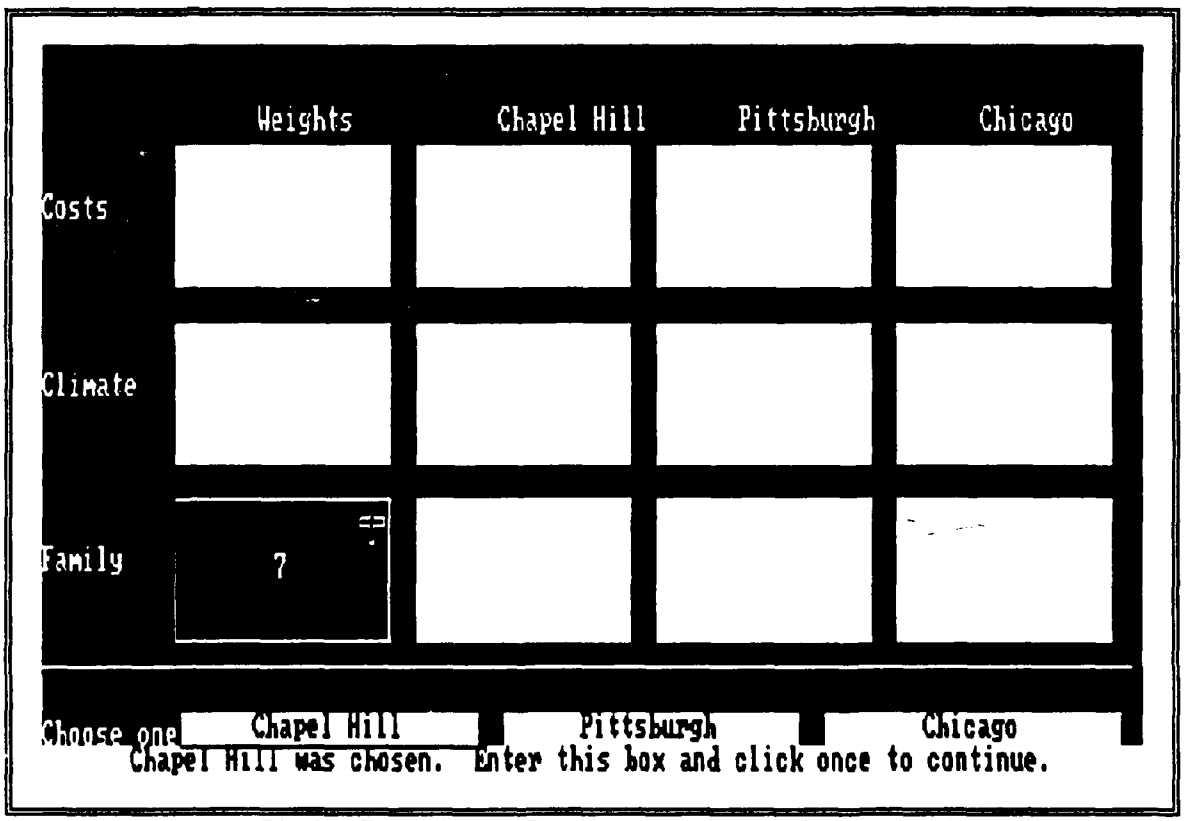

**Display Example 9**: Sample Matrix Schema

```
@BEGIN <FILE>
@BEGIN <MATRIX>
@TITLE <"DEMO MATRIX SCREEN">
@SET <ALTERNATIVES = 4;ATTRIBUTES = 3>
@SET <ALT[1]="Newport";ALT[2]="Chapel Hill";
    ALT[3]="Pittsburgh";ALT[4] = "Chicago">
@SET <ATTR[1]="Costs";ATTR[2]="Climate";ATTR[3]="Family">
@SET <BOX[1,1]="Expensive";BOX[1,2]="Excellent";BOX[1,3]="YES";
    BOX[2,1]="Moderate";BOX[2,2]="Good";BOX[2,3]="Yes";
    BOX[3,1]="Moderate";BOX[3,2]="Fair";BOX[3,3]="No";
    BOX[4,1]="High";BOX[4,2]="Poor";BOX[4,3]="No">
@END <MATRIX>
@END <FILE>
```

**Input Example 9**: Input Format for Matrix Schema

## 7.6 Gamble Schemas.

There are four variations on the gamble schema, each providing a different way of expressing preferences. The sub-schemas are (1) Probability Equivalence, (2) Certainty Equivalence, (3) Attractiveness




**Display Example 10**: Transposed Matrix with Suppressed Alternative

```
@BEGIN <FILE>
@BEGIN <MATRIX>
@SET <TRANSPOSE = on>
@TITLE <"Demo matrix screen with weights">
@SET <ALTERNATIVES = 4; ATTRIBUTES = 3; SUPPRESSED = 1>
@SET <ALT[1] = "Weights"; ALT[2] = "Chapel Hill";
    ALT[3] = "Pittsburgh"; ALT[4] = "Chicago">
@SET <ATTR[1] = "Costs"; ATTR[2] = "Climate"; ATTR[3] = "Family">
@SET <BOX[1,1] = "10"; BOX[,,2] = "5"; BOX[1,3] = "7";
    BOX[2,1] = "Moderate"; BOX[2,2] = "Good"; BOX[2,3] = "Yes";
    BOX[3,1] = "Moderate"; BOX[3,2] = "Fair"; BOX[3,3] = "No";
    BOX[4,1] = "High"; BOX[4,2] = "Poor"; BOX[4,3] = "No">
@END <MATRIX>
@END <FILE>
```

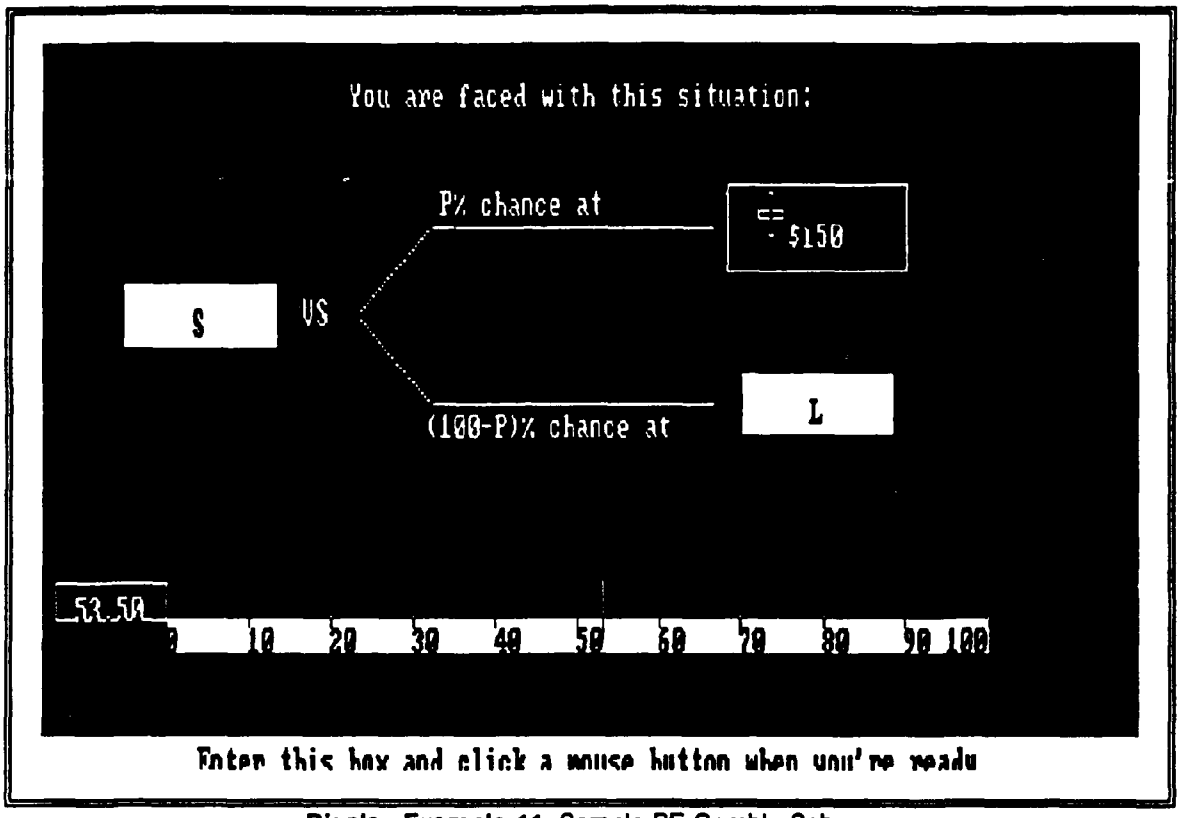
**Input Example 10**: Input format for Transposed Matrix with Suppressed Alternative

Ratings, and (4) Bidding. Each sub-schema presents a two-outcome gamble in a decision tree format. The probability equivalence sub-schema also presents a certain outcome alternative. The names of the four sub-schemas listed above are descriptive of the different responses that are requested of the subject.

These are reflected in the default response modes. This feature is useful since it has been shown that different response modes can generate different preference orders (Lichtenstein & Slovic, 1971). Johnson, Payne, and Bettman (1988), and Schkade & Johnson (1988) have used MOUSELAB to examine preference reversals.

The relevant variables are slightly different across the four sub-schemas. Regardless of sub-schema, a gamble schema specification begins and ends in the usual fashion: @BEGIN<GAMBLE> and @END<GAMBLE>. The sub-schema is selected with a command such as @SET<GAMBLEMODE = PE>. The value PE stands for the Probability Equivalence sub-schema. The other possible values for GAMBLEMODE are CE (Certainty Equivalence), ATT (Attractiveness Rating), and AOB (Amount of Bid). GAMBLEMODE is a local variable with a program default value of PE.

For the PE sub-schema, MOUSELAB must be given a sure amount, the greater payoff of the gamble, and the lesser payoff of the gamble. The command @SET<SUREAMOUNT = "$75"; HIGHPAY = "150"; LOWPAY = "$0"> assigns values to the appropriate variables. Note that the amounts are actually text strings. See Display Example 11 and Input Example 11 for a sample PE Gamble Schema.




**Display Example 11**: Sample PE Gamble Schema

The other three sub-schemas are slightly more complex in terms of the information that must be supplied to the program. For the CE, Attractiveness, and Amount of Bid sub-schemas you will need to assign values to four variables specifying (1) the greater payoff, (2) the lesser payoff, (3) the probability of the greater payoff, and (4) the probability of the lesser payoff. The command @SET <HIGHPAY = "$100"; HIGHPAYPROB = "2/10"; LOWPAY = "$0"; LOWPAYPROB = "8/10"> assigns values to the appropriate variables. Again, note that the values are text strings which will actually appear within their respective boxes on the screen.

```
@BEGIN <FILE>
@BEGIN <GAMBLE>
@TITLE <"Demo PE Screen">
@SET <GAMBLEMODE = PE>
@SET <SUREAMOUNT = "$75"; HIGHPAY = "$150"; LOWPAY = "$0">
@END <GAMBLE>
@END <FILE>
```

**Input Example 11**: Input Format for PE Gamble Schema

Moreover, when using the CE sub-schema, the TITLE command must be used to indicate the type of certainty equivalence problem being specified. The specified title must be either "Gain" or "Loss". Use the phrase which best describes the type of problem being presented to the subject.

The default response mode for gambles is SCALE. Depending on the sub-schema invoked, the user must specify some aspects of the scale. The PE sub-schema requires nothing in the way of scale specifications when using the default response mode. It automatically presents the subject with a probability scale ranging from 0 to 100. The other three sub-schemas require a full scale specification as described in Section 7.3. A special feature of the AOB sub-schema, however, is that a scale is automatically anchored by the actual greater payoff and lesser payoff values of the gamble. This ensures that the response is within the values of the gamble, i.e. the logical range defined by the payoffs. If the lesser payoff is a negative amount, then the lower endpoint of the response scale is set at $0.

Also note that if no RESPONSELINE is specified for the scale in the Attractiveness and AOB sub-schemas, MOUSELAB inserts "Attractiveness" and "Amount of Bid" respectively in the RESPONSELINE location. Input Examples 11.1 and 11.2 contain input specifications for CE and AOB sub-schemas, respectively, with SCALE response modes.

## 7.7 MRC (Multiple Risky Choice) Schema.

The MRC schema is the most complex of the schemas available with the MOUSELAB program. With the MRC schema, any number of sets of gambles can be specified, each set of gambles having any number

```
@BEGIN <GAMBLE>
@TITLE <"Gain">
@SET <GAMBLEMODE = CE; ANCHORMODE = ON; ANCHORVALUE = 25>
@SET <HIGHPAY = "$100"; HIGHPAYPROB = "2/10";
    LOWPAY = "$0"; LOWPAYPROB = "8/10">
@SET <LABELS = 5>
@SET <PUTLABEL[1] = 0.0; LABEL[1] = "0";
    PUTLABEL[2] = 0.25; LABEL[2] = "25";
    PUTLABEL[3] = 0.5; LABEL[3] = "50";
    PUTLABEL[4] = 0.75;LABEL[4] = "75";
    PUTLABEL[5] = 1.0; LABEL[5] = "100">
@END <GAMBLE>
```

**Input Example 11.1**: Input format for CE Gamble Schema

```
@BEGIN <GAMBLE>
@TITLE <"Demo Amount of Bid">
@SET <GAMBLEMODE = AOB; ANCHORMODE = OFF; ANCHORVALUE = 0>
@SET <HIGHPAY = "$33"; HIGHPAYPROB = ".7";
    LOWPAY = "11"; LOWPAYPROB = ".3">
@SET <LABELS = 2>
@SET <PUTLABEL[1] = 0.0; LABEL [1] = "$L";
    PUTLABEL[2] = 1.0; LABEL [2] = "$G">
@END <GAMBLE>
```

**Input Example 11.2:** Input Format for AOB Gamble Schema

of outcomes, and with each set of outcomes defined on any number of attributes (the first attribute value per outcome would be used to specify the probability of that outcome). The only limit on the number of sets, gambles, or outcomes used is the size of the screen. The gambles can be displayed in either a horizontal or vertical orientation. Finally, the MRC schema works with the move checking feature. This schema was designed with risky decision problems in mind. However, it can also be used to present nonrisky alternatives.

As before, an MRC display definition is bracketed by @BEGIN<MRC> and @END<MRC> commands. A display title may be sent to the output file in the usual fashion.

In order to process an MRC schema, MOUSELAB must be given the number of gambles (alternatives) in the set, the number of outcomes of a gamble, and the number of attributes per gamble. All values must be positive integers. To specify the number of gambles in the set, a command such as @SET<GAMBLES =3> is used. The command @SET<OUTCOMES = 2> indicates the number of outcomes every gamble in the set will have. The number of attributes per outcome is specified by @SET<ATTRIBUTES = 3>. The last three commands describe an MRC schema with three gambles, each with two outcomes, each outcome with three attributes. Once again, it is sensible to consolidate commands, yielding @SET<GAMBLES = 3; OUTCOMES = 2; ATTRIBUTES = 3>.

Again, there are no limitations in terms of program logic on the number of gambles, outcomes, and attributes that can be specified for an MRC display. The graphic capabilities of the machine, however, do limit the quality of display of very complex schemas. The appearance of complex choice problems should be judged on a case-by case basis.

Each gamble should be la.ed. The command @SET<GAMBLE[1] = "Gamble 1"> indicates that

the first gamble will be labeled Gamble 1. Labels should be specified for the remaining gambles in similar fashion. The gamble names will appear at the top of the screen.

Each box should also be labeled. The command @SET<BOXLABEL[1,2,1] = "Box 2"> informs the program that the box corresponding to the second attribute of the first outcome in Gamble 1 should be labeled Box 2. The first index of a BOXLABEL variable refers to the outcome, the second index refers to the attribute, and the third to the gamble, i.e. BOXLABEL [outcome,attribute,gamble]. The box labels appear in reverse video on all "closed" boxes.

Finally, the contents of each box must be specified. The command @SET<BOX[2,1,3] = "$250"> indicates that the contents of the box corresponding to the third attribute of the first outcome in the second gamble should be $250. The first index in an MRC BOX specification refers to the gamble. The second index refers to the outcome while the third index refers to the attribute, i.e. BOXLABEL [gamble,outcome,attribute].

As noted earlier, box refererences in the output file are in the form of single numbers. It is therefore important to understand this single index numbering scheme. The box numbers for a 3 X 2 X 3 display are given below:

```
      ONE          TWO          THREE
   - 1 - 2 - 3    7 - 8 - 9    13 - 14 - 15
X            X            X
   - 4 - 5 - 6   10 - 11 - 12   16 - 17 - 18
```

For consistency, the boxes are numbered in the same order regardless of display orientation. To specify vertical orientation, the command @SET<ORIENTATION = VERTICAL> would be used. To produce the orientation above, one would specify @SET<ORIENTATION = HORIZONTAL>. ORIENTATION is a local variable with a program default value of VERTICAL. With a vertical orientation, the box numbers above would look like this:

| ONE | | TWO | | THREE | |
|---|---|---|---|---|---|
| X | | X | | X | |
| 4 | 1 | 10 | 7 | 16 | 13 |
| 5 | 2 | 11 | 8 | 17 | 14 |
| 6 | 3 | 12 | 9 | 18 | 15 |

The single index box numbering schema is also used by the move checking feature for specifying the legal move sequences.

The default response mode for MRC schemas is BOXES. The gamble names are automatically used as the labels for the choice boxes. As with the matrix schema, there is no need for the user to specify anything when using the MRC default response mode.

Again, with a vertical orientation, the inputs would be the same; only the actual display would change. The single index box numbering schema is also used by the move checking feature for specifying the legal move sequences.

## 7.8 The Time Pressure Feature.

The time pressure feature can be used with any of the schemas. To turn on the feature, the command @SET<CLOCK = ON> is used. CLOCK is a local variable with a program default of OFF. As always, the values YES and NO may be substituted for ON and OFF respectively.

The user may specify where the clock should appear on the screen. The location of the clock image is specified in terms of an (x,y) coordinate pair indicating the location of the center of the clock face. As before, the x coordinate refers to number of columns to the right and ranges from 1.0 to 80.0; the y coordinate refers to number of rows from the top and ranges from 1.0 to 24.0. These coordinates may also be given in fractional units (i.e., expressed in real numbers).

The command @SET<XCENTER = 7.0; YCENTER = 3.0> places the center of the clock on the third line down and 7.0 character positions to the right. We suggest this location when using the time pressure feature with the gamble schema; it places the clock in the upper left corner of the screen. With large

matrices one might try (6.0,2.0). These are only suggestions, however. The clock can be placed anywhere it looks good on the screen. (See Display Example 6). XCENTER and YCENTER are also local variables. Their default values are 7.0 and 3.0 respectively.

The researcher chooses what will happen when time expires. The command @SET<ENDSTATUS = NOCHANGE> instructs the program to print the message "Please make a choice or indicate a value" and record the fact that the countdown ended in the output file. The subject is allowed to continue normal search through information boxes and normal response. On the other hand, the command @SET<ENDSTATUS = CLOSEDBOXES>, records the same messages as above but does not allow the subject to search for additional information. All boxes are forced closed (even if the subject is inside one) when time expires. The subject is still allowed to make a response. The command @SET<ENDSTATUS = CLOSEDCHECK> does the same things as the CLOSEDBOXES option with the additional features of beeping when the subject enters a box that is not a response box and recording that fact in the output file. In other words, the behavior of the subject after the countdown ends is monitored. ENDSTATUS is a local variable with a program default value of NOCHANGE.

The BEEPSTATUS variable indicates whether a beep should sound when time expires. The command @SET<BEEPSTATUS = ON> instructs the program to beep at that time. BEEPSTATUS is also a local variable. Its default value is OFF.

Finally, one selects the amount of time to count down in seconds. The command @SET<TIME = 60.0> indicates a countdown of 60 seconds. The TIME variable accepts fractions of seconds, i.e. real numbers. As is the case for all other time pressure variables, TIME is local. Its program default is 5. Note that since all time pressure variables are local, one can avoid constant respecification of their values by assigning their values with a SET command in between schemas.

The clock closes all boxes at time 0. If the subject is in a box and the NOCHANGE option was selected, the box will re-open immediately. This was done to aid the analysis of the time pressure output using the BISECT program. The output file will always show the line like:

97 30.00 1.00 (The countdown ended here)

where 30.00 is the elapsed time and 1 is the current response. No matter which time pressure option has been selected, the position of the cursor when the countdown ended is recorded.

The clock starts timing just after it has been drawn. This is when the boxes can be opened. There will be a slight discrepancy between the time you set in the schema input file and the actual time recorded in the output file. This reflects the fact that the program takes a few milliseconds to make sure that all the boxes are closed, print the ending message, beep (if selected), and record to the output file. However, the clock itself ends on time and the search boxes are closed immediately.

## 7.9 Move Checking.

As noted earlier, this feature can be used to make sure a subject enters boxes only in a certain order, for example that of comparison of all alternatives for each attribute. If the subject tries to enter a box that is not in the specified sequence, the program will beep and the box will remain closed. To use this feature, you must turn it on in the input file and construct a move file. The command @SET<MOVEMONITOR = ON> engages move checking. MOVEMONITOR is a local variable with a default value of OFF. The move file contains one line for each box to be entered, in the order they are to be entered. Note that box references are in terms of a single box number. An example of a move file is given below.

```
@begin (This is a demo move file)
1  (Move files allow for comments to appear on each line)
2  (The numbers 1,2, etc., are the box numbers in correct order)
5
6:4  (As a default value, the program will beep after 1.25 sec.)
3:4 (However, you can make the time to beep anything you want, e.g., 4 seconds.)
@end
```

The ":4" sets the time before a beep to 4 seconds. This feature allows you to set different times for different moves. The comments placed in an input file also appear in the output file when that move has been made. This can aid in the analysis of your results.

The sequence of legal moves is updated by the order of moves and not by the times or time in a legal box. For example, in the demo move file above, a subject can enter box 1 as often as he/she likes. This is perfectly legal. But, once the subject enters box 2, he/she cannot reenter box 1.

In most cases the move checking option treats the response (choice) boxes as always legal moves. That is, a subject can enter and leave a response box at any time. However, if you want to define only one

legal response box then you can add the following line to the move file:

@respsevere=true

This line can appear anywhere in the move file. However, you would have to follow that command at some point with the number of the legal response box. At that point, a subject entering any response box other than the legal one will find that the box does not open, and there will be a beep. This event will also be recorded in the subject's output file. @RESPSEVERE is useful when training subjects to follow certain rules.

## 7.10 Data Trace Option.

The Data Trace option allows the researcher to suspend tracing of a subject's actions within a display. The output file will simply show the normal screen header along with beginning and ending times for that display. The command @SET<DATATRACE = OFF> suspends data tracing. DATATRACE is a local variable with a program default value of ON. In the case of text schemas with no response mode, however, MOUSELAB automatically suspends data tracing since, by definition, there can be no subject activity to trace. Again, the data trace option is most useful during instructional parts of an experiment, where collection of data is usually unnecessary.

## 7.11 Scale Tracking.

The scale tracking feature gives the researcher a record of changes in the direction of scale adjustment. Each change in direction is recorded in the output file with a box number of 96 along with the time at which the change occurred and the value of the scale. Obviously, scale tracking can only be used in conjunction with the SCALE response mode. The command @SET<SCALETRACK = YES> activates the scale tracking feature. SCALETRACK is a local variable with a default value of NO.

## 7.12 Open Boxes.

The command @SET<BOXES = ON> displays the contents of all boxes within a given screen. This feature is useful for instructional purposes. BOXES is a local variable, and its default value is OFF.

## 7.13 Local Variables and the RESET Command.

Fifteen MOUSELAB variables are local variables. These variables are automatically given default values at the outset of the program. A list of these variables and their program supplied defaults is given below:

| Variable | Default Value |
|---|---|
| 1. ANCHORMODE | OFF |
| 2. BEEPSTATUS | OFF |
| 3. BOXES | OFF |
| 4. CLOCK | OFF |
| 5. ENDSTATUS | NOCHANGE |
| 6. GAMBLEMODE | PE |
| 7. MOVEMONITOR | OFF |
| 8. ORIENTATION | VERTICAL |
| 9. RESPONSEMODE | DEFAULT |
| 10. SCALERANGE | OFF |
| 11. SCALETRACK | OFF |
| 12. TIME | 5.0 |
| 13. TRANSPOSE | NO |
| 14. XCENTER | 7.0 |
| 15. YCENTER | 3.0 |

When MOUSELAB creates a new display, it makes copies of all local variables. It is these copies along with their preassigned values which are referenced within individual display specifications. As a result of this procedure, all changes made to the value of a local variable within a display specification are local and affect only that display. The copies disappear at the end of that display.

By using the SET command between display definitions, the user can alter the default values of any or all local variables. Once this is done, the copies of the variables used in subsequent display definitions will automatically contain the new default values.

The command @RESET is used between display definitions to return all local variables to the original program defaults listed above. Note that RESET cannot be used on a single variable; it operates on all of them.

## 7.14 Keyword Precedence.

Abbreviations of input language keywords are permitted. If the abbreviation is unique and could not match another keyword, there is no problem. If the abbreviation could apply to more than one keyword, however, caution must be exercised. When MOUSELAB attempts to identify a keyword, it does so by checking an internal list of legal keywords alphabetically. If an abbreviation could refer to more than one keyword, the one selected as a match will be the first encountered in the alphabetic search. It is important to keep this in mind when using abbreviations, particularly since MOUSELAB does not give warnings in multiple match situations; it simply chooses the first legal keyword that matches the abbreviation.

Table 1 contains a list of MOUSELAB keywords in alphabetical order to help you determine safe abbreviations. The minimum abbreviation is underlined. We find that using complete keywords greatly facilitates understanding MOUSELAB programs.

**TABLE 1**: MOUSELAB Keywords (Minimum Abbreviation Underlined)

| | | | |
|---|---|---|---|
| ALTERNATIVE | COMMENT | MOVEMONITOR | SCALELEFT |
| ALTERNATIVES | DATATRACE | MRC | SCALEMAX |
| ANCHORMODE | DEFAULT | NO | SCALEMIN |
| ANCHORVALUE | END | NOCHANGE | SCALERANGE |
| AOB | ENDSTATUS | OFF | SCALESIZE |
| ATT | FILE | ON | SCALETRACK |
| ATTRIBUTE | GAMBLE | ORIENTATION | SCREENTEXT |
| ATTRIBUTES | GAMBLEMODE | OUTCOMES | SET |
| BEEPSTATUS | GAMBLES | PE | SUPPRESSED |
| BEGIN | HIGHPAY | PUTLABEL | SUREAMOUNT |
| BOX | HIGHPAYPROB | RESET | TEXT |
| BOXES | HORIZONTAL | RESPONSE | TIME |
| BOXLABEL | LABEL | RESPONSELINE | TITLE |
| CE | LABELS | RESPONSEMODE | TRANSPOSE |
| CLOCK | LOWPAY | RESPONSES | VERTICAL |
| CLOSEDBOXES | LOWPAYPROB | SCALE | XCENTER |
| CLOSEDCHECK | MATRIX | SCALEBOTTOM | YCENTER |
| | | | YES |

# 8.0 The Output File.

A sample of the MOUSELAB output format is contained in Table 2: (The headings do not occur in a real output file.)

The first line in the example above is a header that identifies the screen (schema) that generated the responses that follow. The next line is numbered 100. It marks the beginning of the output from a particular screen. Notice that the time and response are 0.000 and 0.00, respectively. The next lines are a record of the mouse cursor movements. The Boxnumber is the number of the box that the cursor was in. The boxnumbers always come in pairs. For example, the pair of 3s above means that the subject entered and left box number 3. If a subject had entered and left and then entered and left the same box you would see

**Table 2**: Sample MOUSELAB Output

| BOXNUMBER | TIME | RESPONSE | COMMENT |
|---|---|---|---|
| 99 | scr # 1 | Demo Screen #1 | |
| 100 | 0.000 | 0.00 | |
| 1 | 0.879 | 9999.00 | |
| 1 | 0.988 | 9999.00 | |
| 3 | 0.988 | 9999.00 | |
| 3 | 1.784 | 9999.00 | |
| 5 | 2.202 | 9999.00 | |
| 5 | 4.598 | 9999.00 | |
| 8 | 4.598 | 2.00 | |
| 8 | 4.954 | 2.00 | |
| 100 | 5.230 | 2.00 | |

something like 3....; 3....; 3....; 3.... on four separate lines. The next number on a line is the time at which the cursor entered or left the box. Time is counted from the beginning of the display. The third number indicates a possible response. That is, if the associated box is a choice or response box rather than an information box, then a number other than 0 would be listed. For a choice box, the number listed corresponds to the alternative being considered, as listed from left to right on the bottom of the screen. For a scale response, the number listed corresponds to the scale value. The value 9999.00 signals that the subject has not yet made a response on the scale. The last item on an output line could be a comment (not shown in the example). This is a textstring taken from a move file, if that feature had been selected. The

last line of the output from a particular screen is also numbered 100. It marks the end of that particular set of responses and gives a record of the total time viewing the screen and the final response (choice) indicated by the subject.

In addition to the standard output discussed above, four other lines will be written to the output file, depending on the MOUSELAB program features you have selected. The first marks the end of the countdown under the time pressure condition.

Example:

97 10.051 0.0 (The countdown ended here)

The first number on the line just identifies it. The second number is the time. The third number is the current response (choice) if any. Finally, there is the comment that the countdown has ended.

The second is a variation of this line and is used by the text schema to indicate elapsed reading time. The output from a typical text screen would look like this:

99 scr #1 Demo

100 0.000 0.000

100 3.725 0.000 (text reading time)

The third special feature output line is for the movechecking condition. It uses essentially the same format. Example:

98 2.470 0.0 (buzzed in box 10)

The comment at the end lets you know that the subject was in a wrong box for more than the specified period of time and which box he or she was in.

The final special output line indicates a change in the direction of response scale adjustment when the SCALETRACK feature is engaged. Example:

96 22.746 36.21 (change in scale adjust direction)

The line specifies, from left to right, the special identifying number, the time, the scale value when direction of adjustment changed, and a descriptive comment. Also, a line starting with a 0 occurs when the subject enters or leaves the scale. Example:

0 25.785 38.24

96 26.394 35.91

0 27.132 45.36

These lines specify that the subject entered the scale at a value of 38.24, adjusted down to 35.91, and then left the scale at 45.36.

An output file can be analyzed directly. However, it is often useful to use the BISECT program that is part of the MOUSELAB package to make the task of analysis easier. BISECT determines the total time the box was open, the current response, and comments for each search (fixation) of a box at a particular point in the sequence of acquisitions. In other words, it compresses the standard output file from the MOUSELAB program.

# 9.0 BISECT.

BISECT is a utility program that accepts as its input any output file produced by MOUSELAB v4.2. As its output, BISECT produces a "fix" file which, using as input the MOUSELAB output file on page 40, would have the general format illustrated in Table 3: (Again, the headings are not part of the BISECT output file.)

**Table 3**: Sample BISECT Output

| SUBJECT | TRIAL | BOX NUMBER | BOX TIME | PLUSTIME | SEQUENCE | RESPONSE |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 0.109 | 0.109 | 1 | . |
| 1 | 1 | 3 | 0.796 | 1.214 | 2 | . |
| 1 | 1 | 5 | 2.396 | 2.396 | 3 | . |
| 1 | 1 | 8 | 0.356 | 0.632 | 4 | . |
| 1 | 1 | 100 | 5.230 | 0.000 | 5 | 2.00 |

SUBJECT is the subject number which, as will be explained later, is determined by the user. TRIAL is the screen number. BOXNUMBER and BOXTIME are the same as described in section 8.0. If the same box is reentered 1 or more times, the BOXNUMBER will only be listed once and BOXTIME will be the sum of the individual boxtimes. PLUSTIME is calculated by subtracting the entry time of the current box from the entry time of the next box. Plustime is the amount of time until the next box acquisition. If the next box acquisition does not exist, plustime is 0.0. SEQUENCE is the order of acquisition, while RESPONSE is the

same as described in section 8.0.

The last line of a screen will always have boxnumber '100', indicating when the subject left the screen. In addition, the contents of any @TITLE command will always be placed at the end of the first line of BISECT output for that display. This can be useful since data concerning experimental stimuli can be included within the BISECT output file and can be used for data analysis programs.

Other programs written in SAS or some other suitable language can be used to analyze the results of BISECT. Here is one method, often used in our experiments. Typically, the BISECT output file is uploaded from the microcomputer to a mainframe computer. A SAS program inputs this file and produces a temporary data set generating appropriate process measures. This data set can then be summed across a trial using the PROC MEANS procedure using the 'sum' option. The results of this are merged with a data set describing the stimuli to create any other necessary variables such as average acquisition time, alternative variance, attribute variance, etc. Final data analysis is then produced by using SAS procedures such as Proc GLM.

Like MOUSELAB, the BISECT program runs under IBM PC/DOS. Place the disk containing 'BISECT.EXE' in drive A. The user then types BISECT and presses the return key. BISECT will then prompt the user for three types of information. First, it will ask for the name of the input file. This can be any MOUSELAB v4.2 output file. Second, it will ask for the name of the output file. This can be any valid PC/DOS file name. Finally, it will ask for the subject number.

## 10.0 Randomizing and Counterbalancing in MOUSELAB.

The MOUSELAB program itself does not do the kinds of randomization and counterbalancing usually used in psychological experimentation. Usually this was done externally to the program, either by hand or by writing a special purpose program. The input would be a "master" experimental file which would produce many rearranged output files, one per subject, which would serve as input files to MOUSELAB.

With this release, we make available a generalized solution, consisting of a preprocessor which can produce randomized and counter-balanced files for input to MOUSELAB. As described below, a post processor is also available to unscramble the files.

The preprocessor adds three command pairs (BLOCK, RANDOMIZE, and COUNTERBALANCE) to the MOUSELAB input language. The experimenter simply needs to add these commands within a normal MOUSELAB input file, creating a "master" input file. The preprocessor then takes as input this master input file and a unique subject number, and produces a MOUSELAB input file, removing the new "ordering" commands, but leaving the appropriate sections randomized and counterbalanced. In addition, the preprocessor also produces a file showing the nested nature of the input file -- helpful in debugging -- and an auxiliary file showing the new order of the schemas. The preprocessor is case insensitive, as the other MOUSELAB routines are.

BLOCK: A line beginning with "@BEGIN<BLOCK>" will signify the beginning of a block or section. A line beginning with "@END<BLOCK>" will signify the end of that block. Anything in between these two lines will be treated as an indivisible unit and will remain as a block in the produced MOUSELAB input file. Note, also, that any global command, schema, or preprocessor commands may be nested within a block. For example, assume an experiment contains three different groups of schemas: MRC, Matrix, and PE Gamble. The experimenter would like to randomize the order of the groups while keeping the different schema types segregated. The master input file, abbreviated, would have the following structure: (Indentation is used here only to denote nesting and is not necessary.)

```
@BEGIN<RANDOMIZE>
        @BEGIN<BLOCK>
                MRC schema #1
                .
                .
                MRC schema #x
        @END<BLOCK>
        @BEGIN<BLOCK>
                Matrix schema #1
                .
                .
                Matrix schema #y
        @END<BLOCK>
        @BEGIN<BLOCK>
                PE gamble schema #1
                .
                .
                PE gamble schema #z
        @END<BLOCK>
@END<RANDOMIZE>
```

RANDOMIZE: A line beginning with "@BEGIN<RANDOMIZE>" signifies the beginning of a randomize

pair, and a line beginning with "@END<RANDOMIZE>" signifies the end of the pair. Any schemas, blocks, and preprocessor command pairs contained between these two lines will be randomized. Note that schemas and preprocessor command pairs are treated as indivisible units by the randomize command. For example, if an experimenter wished to randomize three blocks of schemas, each block containing different types of schemas, the master input file would contain the following structure:

```
@BEGIN<RANDOMIZE>
        @BEGIN<BLOCK>
                SCHEMA #1-#x
        @END<BLOCK>
        @BEGIN<BLOCK>
                SCHEMAS #1-#y
        @END<BLOCK>
        @BEGIN<BLOCK>
                SCHEMAS #1-#Z
        @END<BLOCK>
@END<RANDOMIZE>
```

In randomization, the preprocessor uses the subject number as the random number generator seed.

COUNTERBALANCE: "@BEGIN<COUNTERBALANCE>" and "@END<COUNTERBALANCE>" are the last pair of preprocessor commands. Any schema or preprocessor command pair between these two lines will again be treated as an indivisible unit. The preprocessor will automatically count the total number of indivisible units contained between the "counterbalance" commands. If the master input file contains N units within the pair, the preprocessor will write to the new input file the Mth through Nth units, and then the 1st through M-1th units. M is equivalent to the remainder of N (number of counterbalanced units) divided by the subject number. Again, any schemas or other preprocessor command pairs can be nested within a Counterbalance pair.

Usage of the preprocessor is straightforward. Again, before using the preprocessor, the master input file must be tailored using the three commands explained above. Then, after starting the preprocessor, RANDOM.EXE, the user will be asked to type in the name of the master input file. Then, the preprocessor will prompt the user for a subject number. The preprocessor will then proceed to create three new files ending in ".inp",".aux", and ".dbg". The master input file's base name, with the subject number behind it, will be used for the base name of the three new files. Thus, if the master input file was named "test.doc", and the entered subject number was 23, "test23.inp", "test23.aux", and "test23.dbg" would be created. The ".inp" file contains the new MOUSELAB input file. The ".aux" file contains the order of the scrambled screens --

this file is used by the postprocessor to unscramble the MOUSELAB data output and must not be deleted. If a mistake has been made using the preprocessor commands, the program will terminate. To aid in locating the mistake, the ".dbg" file contains a copy of the master input file, but with indentation and indexing to illustrate any nested structures. After a file has been successfully created by the preprocessor, the ".dbg" file is no longer needed by the pre\post processors and may be deleted.

The postprocessor, simply rearranges the output from a MOUSELAB run. The postprocessor prompts the user for the name of the output file, and then searches for an ".aux" file with the same base name. It will proceed to unscramble the output file, writing to a new output file. The new output file is given the same base name, but will have a ".rat" extension (an acronym for raw data). Output from all screens and schemas will be in their original master file order (i.e. the order before the preprocessor was used). In addition, the postprocessor alters the first line of each schema, denoted by a 99. The 99 line might look like this:

99 scr# 23 Original #4.

This was the 23rd screen the subject viewed, but was the fourth screen in the master input file. Usually, to perform data analysis, rearranging the data files into a standard order (that of the master file) is necessary.

The postprocessor is named URANDOM.EXE. After starting it, the post processor will simply prompt the user for the output file name. Execution will terminate if an ".aux" file of the same name is not found.

## 11.0 Summary.

As decision researchers have become more interested in explaining the processes of judgment and choice, there has been a concomitant search for new methods of studying decision behavior. One technique that has proven valuable is the monitoring of information acquisition behavior. This technique involves setting up the decision task so that the decision maker must view or select information in a way that can be easily monitored. The procedures used to study information acquisitions and decisions have ranged from simple information boards constructed of cardboard and 3 x 5 cards to sophisticated eye-movement apparatus. Unfortunately, the simple techniques may impose an unspecified effort and time cost on acquiring information. Eye-movement recording, which reduces the effort and time costs, has the disadvantage of involving expensive equipment that is difficult to use.

This report has documented a new procedure for monitoring information acquisition behavior. The procedure is based on a micro computer-controlled pointing device called a mouse. The procedure also employs a number of flexible graphics and data recording routines. There are several thousand different display and experimental condition combinations that can used. Included are relatively new capabilities, such as checking the order of information acquisitions to ensure that the subject is following a specified decision strategy. Using the MOUSELAB Decision Laboratory Software offers a decision researcher a viable way to obtain the high temporal density of observations regarding a subject's pre-decisional behavior that appears necessary to develop and test process models of decision behavior.

# 12.0 References.

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# 13.0 Appendix A.

**Appendix A: Licensing Agreement**

We request a $25.00 fee for MOUSELAB disks and manual. This should be payable to the University of Pennsylvania. This covers only our reproduction costs and labor. In return, permission to use the MOUSELAB software is given for not-for-profit research and educational uses only. Please contact one of the authors of this document if you intend to use this software in any other application.

While we distribute this software on an at-cost basis for research and educational use, we would appreciate if you do not copy the software or documentation for others. Please ask them to contact us for additional copies. This allows us to provide updates to all users and allows us to monitor usage. If you did not receive this copy from us, please contact us so that we may register you as a user. Thank you.

## Appendix B: MOUSELAB files and their functions

The following is a list of MOUSELAB files included on the distribution diskettes and their functions:

METAWNDO.EXE: Command which installs the graphics driver. MUST be implemented before running MOUSELAB.

MOUSELAB.EXE: The MOUSELAB program itself.

RANDOM.EXE: Contains the preprocessor used to scramble and counterbalance MOUSELAB input files.

URANDOM.EXE: Contains the postprocessor used to unscramble subjects' MOUSELAB raw data output. (Can only be used if original MOUSELAB input files were preprocessed with RANDOM.EXE.)

BISECT.EXE: Program which takes as input MOUSELAB raw output and organizes the data into a form which can then be used for statistical analysis. If RANDOM.EXE was used on a MOUSELAB input file, BISECT should be used only AFTER URANDOM.EXE has been used to unscramble the file.

*.MLI: MOUSELAB input file. DO NOT ALTER BY ANY MEANS.

*.FNT: All files with the .FNT extension are graphics files used by the graphics driver. These files should not be altered.

DEMO4.INP and DEMO4.MOV: MOUSELAB demonstration files used to illustrate the different capabilities of MOUSELAB.

## Appendix C: Time to point the mouse

The time required to point to a box on a screen using a mouse can be described by Fitts Law, a basic equation in the human factors literature.

Fitts Law:
Time to position = $K_0$ + $I_m$ (D/S + .5)seconds.
where D is the distance to the target box, S is the size of the target, $I_m$ = .100 sec/bit, and $K_0$ is a constant.

The size of the target S and the distance between targets D varies across the different displays possible with the MOUSELAB program. Consequently, time to position will differ across the displays. However, it is useful to consider a few displays that will involve large differences in the time to position the mouse cursor in a box.

**Gamble Schema**. The gamble schema involves the smallest number of boxes spread across the greatest width of the screen. The boxes are 1.2 cm high and 3.0 cm wide. They have a maximum distance of 7 cm. For such a display, Fitts Law yields a value of $K_0$ + 245 milliseconds.

**Matrix Schema**. A matrix display involving just two alternatives and two attributes is one that is likely to yield the fastest times to position the cursor. The boxes are 8 cm high and 8 cm wide. They have a maximum distance of 8 cm. For such a display, Fitts Law yields a value of $K_0$ + 82 milliseconds.

Of course, the time to position values above depend on a value for $K_0$. Card, Moran, and Newell (1983) present values for $K_0$ that range from 600 to 1100 milliseconds. However, those values are likely to be overestimates of $K_0$'s for our task. Unlike some of the pointing devices and tasks studied by Card, Moran, and Newell, in our task the subject's hand is always present on the mouse.

## Appendix D: Additional Considerations

### Errors

To err is human, but computer programs are even worse. Therefore, a few words about errors. Errors you may encounter when using MOUSELAB will be of two basic types: program generated errors and machine generated errors. Program generated errors are errors which are detected and handled by MOUSELAB itself. These usually have to do with program start-up parameters and input file formatting. A program generated error message is distinguished by the presence of the word "MOUSELAB" prior to the actual message. These messages refer to problems specific to the MOUSELAB program; they usually result from user mistakes. For example, one such message is "MOUSELAB: unrecognized graphics card." This indicates that the user has specified a graphics card in the start-up parameter list which MOUSELAB is not able to handle. This may result either from a typo or from attempting to use MOUSELAB with a graphics card it cannot use. To correct the problem, the user must fix the typo in the former case or use a different graphics card in the latter.

Machine generated errors are errors which are detected and handled by the operating system. These will usually be the result of a previously undetected bug in the MOUSELAB program. They may, however, also result from creative user mistakes which we failed to anticipate. Machine generated error messages will not have the "MOUSELAB" label prior to the message text. In this case, try to determine if the error message refers to something under your (the user's) control. If it doesn't or if it's just so much gobbledegook, please follow the directions in this appendix under Reporting Bugs.

### Existing Bugs

One existing bug which has not been solved is a time overflow error. Very, very occasionally, elapsed time for a screen may be negative, or, perhaps, into the thousands of seconds. This error usually lasts for only one screen, and then resets itself. We apologize if this error causes any inconvenience. All programmers who have worked on MOUSELAB have been unable to fix this error. (If anyone knows how to solve it, please contact Dr. Johnson.)

### Reporting Bugs

If you discover a bug in the program, either fatal or nonfatal to program execution, please write to

Professor Eric Johnson/MOUSELAB
Marketing Department, SH/DH 1457
The Wharton School
University of Pennsylvania
Philadelphia, PA 19104-6327

Be sure to send COMPLETE information, including a full description of the problem, the full text of the error message (if any), the system configuration, and any other pertinent information regarding the circumstances (e.g., if MOUSELAB consistently bombs when it reaches a certain screen, send a listing of the input file specifications for that screen and the one preceding it).

We also can be reached by computer mail. Any mail should be sent to the following address:

JOHNSON00@WHARTON.UPENN.EDU

Time constraints prevent us from responding to telephone inquiries.

### Other Inquiries

Please direct all other inquiries to Professor Johnson at the above address.

### We Beg Your Indulgence

Please remember that we are not professional software developers. We will do our best to help you, but we make no promises of fast and/or efficient service.

### Coming Attractions

As time marches on, we will be working to enhance MOUSELAB. Our goals include the use of graphics in boxes and the introduction of rudimentary flow of control. Be forewarned, however, that this will most likely be at the expense of upward compatibility. In other words, files which work with version level 4.2 of MOUSELAB may not work with subsequent versions (version 3.0 files, for example, do not work with version 4.2). Constraints on program size and on the amount of time we can devote to it will probably force us to sacrifice upward compatibility for the sake of user friendliness and increased capabilities. We feel this is a worthwhile tradeoff and apologize in advance for any hassles this may cause in the future. Therefore, always keep a copy of this version of the program if you want to be able to use its input files after the next version is released.